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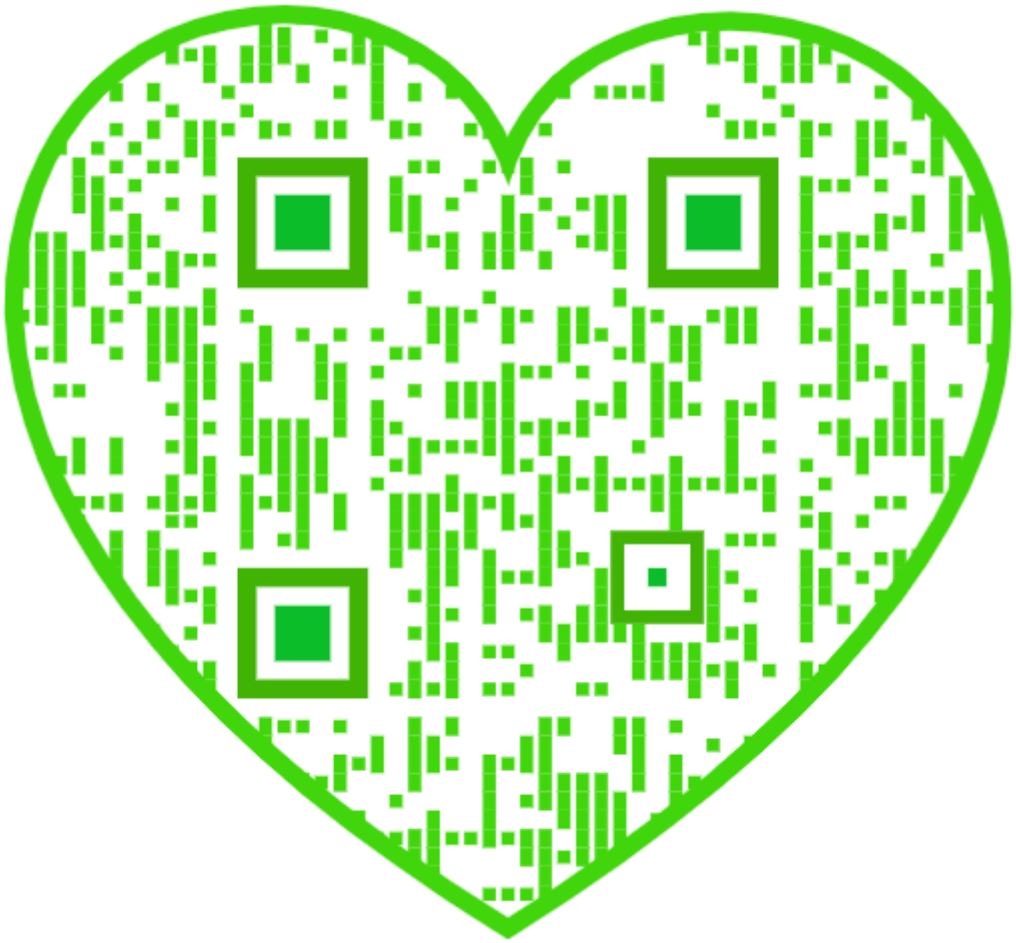
ITS TREATMENT IN HEALTH & DISEASE



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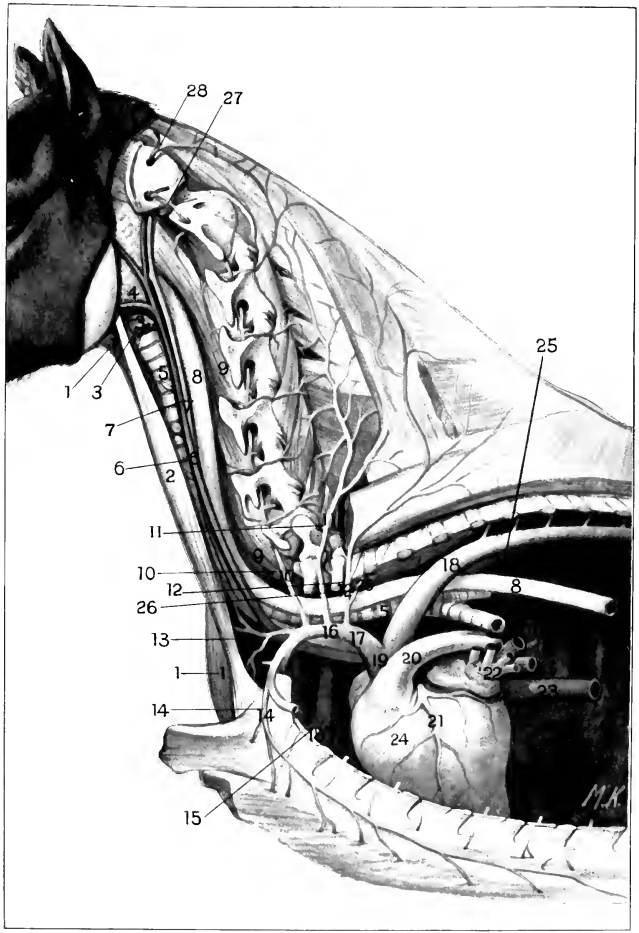

THE ANTERIOR AORTA AND ITS BRANCHES

THE ANTERIOR AORTA AND ITS BRANCHES

1. Sterno-thyro-hyoideus muscle.
2. Sterno-maxillaris muscle.
3. Thyroid gland.
4. Parotid gland.
5, 5. Trachea.
6. Jugular vein.
7. Carotid artery.
8, 8. Œsophagus.
9, 9. Longus colli muscle.
10. Vertebral artery.
11. Superior cervical artery.
12. Anterior dorsal artery.
13. Inferior cervical artery.
14. External thoracic artery.
15. Internal thoracic artery.
16. Axillary artery.
17. Anterior aorta.
18. Posterior aorta.
19. Aorta.
20. Pulmonary artery.
21. Left coronary artery.
22. Pulmonary veins.
23. Posterior vena cava.
24. Heart.
25. Vena azygos.
26. Subcostal artery.
27. Union of retrograde and vertebral arteries.
28. Occipito-muscular artery.

ITS TREATMENT IN HEALTH AND DISEASE

WITH A COMPLETE GUIDE TO BREEDING
TRAINING AND MANAGEMENT

Edited by

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"Examination of Horses as to Soundness" "Glanders, its Spread and Suppression" "Swine Fever"
"Lithotomy or the Removal of Stone from the Bladder of the Horse"

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Albumen.—This substance is not a constituent of healthy urine, although it is sometimes found as a temporary contamination. When existing as a permanent condition it is a matter of serious importance, inasmuch as it indicates the existence of organic disease of some part of the urinary apparatus, most frequently the kidneys.

Albumen is recognized by adding to a small quantity of the suspected urine, in a test-tube, a few drops of nitric acid, when the albumen, being coagulated, falls to the bottom of the glass as a grayish flocculent deposit. Boiling also produces the same effect.

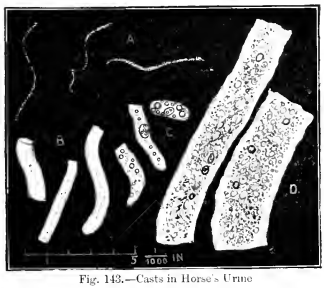


Fig. 143.—Casts in Horse's Urine

A, Mucous casts. B, Small waxy clear casts. C, Casts with fat and oil globules. D, Large granular casts

Mucus.—The whole of the urinary channels being lined by mucous membrane, it is not remarkable that mucus should be found in healthy urine. Sometimes, however, it exists in such amount as to render the fluid thick and ropy, and to impart to it the consistence of thin glue.

This condition is not necessarily associated with serious organic disease, but rather with a state of irritability of the urinary organs generally. It is most frequently seen in old animals, and especially mares. When submitted to microscopical examination the urine in these cases is found to contain small mucous corpuscles entangled in a sticky fluid, together with a number of fine filaments studded with minute granules of carbonate of lime. The latter are derived from the kidney, and represent casts of the urine tubes in which they have been formed.

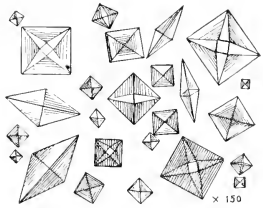


Fig. 144.—Crystals of Oxalate of Lime from Horse's Urine

Casts.—In addition to mucous casts, just referred to, others of various composition are met with as the result of inflammatory disease of the kidneys. Of these some are composed of epithelial cells in various stages of decay, shed from the inner surface of the urine tubes; others are formed of blood corpuscles either alone or mixed with, or enclosed in, epithelial cells, while others are structureless and wax-like (fig. 143).

Oxalate of Lime, although frequently occurring in the urine of healthy horses, is now and again found to exist in large quantities, associated with a disease of an obscure character, to which, for want of a better name, "oxaluria" has been applied. In a case recorded by the late Professor Morton the urine was found to contain this salt in considerable amount (fig. 144).

When first examined, Professor Morton says the pulse was found to be thirty-two in a minute, tone feeble, a peculiarly anxious countenance was observed, and a looking from time to time to the loins, with an expression indicative of pain. The appetite was impaired and capricious, although there was but little loss of flesh. On walking the animal out of the stable, considerable languor and listlessness were evinced, and the slightest exertion produced great fatigue. On his being returned to the stable he immediately placed himself in the position to urinate, and, after making several ineffectual attempts, a few ounces of urine were voided, having a very peculiar smell, and being somewhat viscid. In this case the urine had a light amber colour, and was clear. It gave an acid reaction to test-paper, and its specific gravity was 1·00045. It did not contain albumen, but when examined microscopically was found to contain a large amount of oxalate of lime, in the form of bright octahedral crystals.

The presence of oxalic acid in the urine is believed to arise out of some defect in the digestion and assimilation of the food.

DIABETES, POLYURIA, OR PROFUSE STALING

Definition.—A morbid activity of the kidneys, resulting in an excessive secretion of urine.

Diabetes assumes two forms, distinguished as diabetes **mellitus** and diabetes **insipidus**. The former is characterized by the presence of sugar in the urine, and an increase in the specific gravity. In the latter there is an absence of sugar, and the specific gravity is usually below the normal standard. Diabetes mellitus is rarely seen in the horse.

Causes.—Profuse staling, or polyuria, is sometimes associated with indigestion and suppressed skin function. Hay that has been badly harvested, and by excessive fermentation become heated and "mowburnt", is one of the most frequent causes of the disorder, while in other cases the drinking water may be at fault. Foreign oats and hay are more frequently found to affect the urinary organs of horses in these islands than those grown at home. Debility and exposure to great vicissitudes of climate are also considered as a probable cause. The disorder is usually found to exist without any organic disease of the kidneys themselves.

Symptoms.—In addition to the excessive quantity and the frequency with which the urine is passed, marked thirst is a prominent and lasting symptom. The pulse is weak, the skin loses its gloss, becomes dirty and closely "bound" to the parts beneath. The membranes of the eyes and nose are pale in colour, the appetite capricious, and the breath sour-smelling. The affected animal rapidly loses condition, and sweats under comparatively slight exertion. Moreover, the capacity for work is largely curtailed. The urine, besides being light in colour, has a low specific gravity.

Treatment.—In the early stage, and before excessive debility is present, a mild aloetic aperient may be given as a preliminary measure, and this should be followed by a demulcent diet, consisting largely of linseed tea, with scalded oats of the best description, and good sound bran. The so-called diuretic remedies should in no case be prescribed. Gallic acid or powdered nutgalls, with nux vomica and quinine, may be recommended. This failing, a course of iodide of iron should next be tried, and upon an abatement of the symptoms may be advantageously replaced by a mixture of nitro-hydrochloric acid and infusion of calumba. Belladonna, in the form of extract or tincture, is recommended in cases of some standing. The food should be of the best, and an unlimited quantity of drinking water allowed. The patient will be benefited by a short period of walking exercise in the middle of the day. On no account should he be exposed to wet, or to cold easterly or north-easterly winds. A warm but well-ventilated stable should be provided, and the surface circulation maintained by ample clothing. With proper treatment a few weeks suffice to bring about complete convalescence.

HÆMATURIA OR BLOODY URINE

Urine may become contaminated with blood from various sources. In all cases, however, this condition denotes broken blood-vessels, either as the result of disease or accident. As to the precise seat of the lesion, some sort of opinion may be formed by noting the manner in which the blood is discharged. When coming from the kidney it is uniformly mixed with the urine. If the hemorrhage is from the bladder the blood-stained portion of the urine will most frequently be the last passed in the act of micturition, its greater specific gravity causing the blood to sink to the lowest portion of the organ, and only to be expelled at the final muscular contraction of the viscus. When the source of blood arises from injury to the urethral canal, it is washed out with the first portion of fluid issuing from the bladder.

Causes.—Some cases of bloody urine are caused by injuries, the result of external violence; others may be traced to the presence of calculi (stones) in the kidney or the bladder, and occasionally also in the urethral canal. Structural changes resulting from one or other of the various diseases affecting these organs are accountable for a small percentage of cases.

Treatment.—When hemorrhage is the result of the presence of stone in the bladder or urethral canal, the offending body must be removed by operation. If it arises in the course of disease of the kidney, cold cloths should be applied over the loins, and small doses of tannic acid, with nux vomica, administered two or three times a day. The patient will require to be kept perfectly quiet, and the bowels maintained in a state of activity by light bran diet and two or three tablespoonfuls of linseed-oil morning and evening. Enemas of cold water will also assist in keeping the bleeding in check.

Demulcent drinks, as linseed tea, should take the place of water, but the quantity allowed should not be excessive.

DISEASE OF THE KIDNEYS

Nephritis.—Inflammation of the kidneys of the horse is much less frequent than in man—a difference which no doubt finds explanation in the absence in the one of those serious dietetic and alcoholic abuses which are so commonly prevalent in the other.

Causes.—Chief among these are exposure to cold and wet while the body is heated and fatigued. It is often induced by the habitual administration of cantharides to excite the sexual instinct in travelling stallions. The abuse of diuretic agents, as turpentine, resin, nitre, and oil of juniper, undoubtedly contributes to the number of cases of inflamed kidneys, and it may be accepted as true that the less knowledge carters and grooms possess of the horse, the more frequent will be their use of drugs, and the more powerful those selected.

Inflammation of the kidneys may also result from inflammation affecting the bladder, by extension of the disease along the line of the ureters, or from absorption of cantharides into the blood when applied over large surfaces of the skin for blistering purposes; and it sometimes follows certain forms of blood-poisoning, during which the blood-vessels become blocked, and abscesses develop in the structure of the gland. Severe strains in jumping, and violent efforts at draught, are probably sometimes provocative of the disease.

Symptoms. In this affection the patient shows a frequent desire to stale, but the quantity of urine expelled at any one time is very small,

and the total amount discharged in the twenty-four hours is much less than usual. Attempts to urinate are sometimes made without effect, and the penis is unsheathed and retracted from time to time without any attempt to stale being made. Now and again colicky pains appear, and the animal is restless and essays to lie down. The urine is thick and muddy, and sometimes blood-stained, or it may become charged with pus. Pressure over the loins causes the animal to cringe, and the hind-limbs are moved somewhat stiffly in progression.

As the disease advances there is marked constitutional disturbance, shown by the quick pulse, accelerated breathing, increased temperature, hot and clammy mouth, and the occurrence of patchy sweats. Rigors are sometimes present, the face wears a pained and anxious expression, and the mucous membranes of the eyes and nose are intensely reddened.

Treatment.—This should be commenced by the administration of aloes sufficient to open the bowels freely. The diet should be reduced to bran, with which a little boiled linseed may be mixed, and the tea from the latter will prove a most desirable drink, to which, if possible, the patient should be confined. Where pain is severe, opium may be administered in small repeated doses. Hot cloths to the loins will exercise a soothing influence, and enemas of warm water in which a little extract of belladonna has been dissolved will materially aid in subduing existing inflammation.

Where, as sometimes occurs, there are no conveniences for fomentations, the loins may be stimulated by means of soap liniment and strong ammonia (liquid ammonia). On no account are turpentine and cantharides to be used as local applications. Their absorption into the blood would inevitably aggravate the disease.

INFLAMMATION OF THE BLADDER—CYSTITIS

Definition.—An inflamed condition of the lining membrane, extending more or less to the other structures of the bladder.

Causes.—This disease is the result of some irritant acting upon the mucous membrane by which the organ is lined. The provocative agents are sometimes mechanical, at others they are of a chemical nature; of the former, stone in the bladder is the more common cause. Chemical irritation results in those cases where the urine is long retained, either as the result of paralysis or otherwise, and in consequence undergoes decomposition. It also follows upon the too-free administration of cantharides and croton-oil, or from their absorption by the skin when applied over a large surface. In mares, it may be the result of difficult parturition, where much force has been employed in extracting the fœtus. In-

flammation of the bladder sometimes complicates certain forms of influenza, and attends the development of morbid growths.

The symptoms are those of abdominal pain with frequent shifting of the hind-feet. Urine is discharged in small quantities and often, and the affected animal repeatedly extends himself as if to stale, without effecting his purpose. The penis is unsheathed from time to time and again retracted; this symptom is particularly marked when the disturbance is caused by cantharides or other sexual irritants. In mares the vulva is spasmodically everted from the same cause. If the bladder be pressed upon by passing the hand into the rectum the animal evinces pain by looking round towards the flank. The urine is usually turbid or muddy, and may be blood-stained. Unless relief is afforded, the pulse becomes quick and small, the breathing accelerated, the mucous membrane of the eyes changes from a pale pink to a brick-red hue. The countenance wears a pinched and haggard expression, and general prostration becomes marked and severe.

Treatment should be directed to subdue existing pain and render the urine as little irritating to the inflamed organ as possible. With the latter object bland soothing fluids, consisting of linseed tea, milk, barley-water, and white of egg, should be given. The bowels must be freely acted upon by a dose of aloes, and enemas of warm water, in which a little extract of belladonna and glycerine has been dissolved, will require to be administered two or three times a day. Nothing contributes so much to the relief of the patient as to guard against the accumulation of excrement in the posterior bowel. In some cases it is most desirable that the bladder be washed out from time to time with a warm antiseptic solution, in the preparation of which carbolic acid or perchloride of mercury will be found the most suitable agents. This, however, being an operation requiring special knowledge, should not be attempted by an amateur.

Small, repeated doses of belladonna will be found most useful in reducing the pain and irritability of the diseased organ, and some relief will also be afforded by hot cloths applied across the loins.

Horses having once suffered from inflammation of the bladder are liable to a recurrence of the disease, to avoid which they should be afforded frequent opportunities to stale.

RETENTION OF URINE

Definition.—Partial or complete inability to expel urine from the bladder by the usual natural method.

Causes. It is frequently due to spasmodic constriction of the neck of the bladder, and may also be the result of mechanical obstruction in

the urethral canal. It sometimes occurs as a result of paralysis following on abnormal conditions of the brain and spinal cord. Among the mechanical obstructions may be mentioned enlargement of the prostate gland, the descent of calculi from the bladder into the urethral canal, stricture, morbid growths, swelling of the sheath, &c. Want of opportunity to stale is another frequent cause, as when thoughtless persons drive long distances and neglect to take the animal out of harness. It may be men-

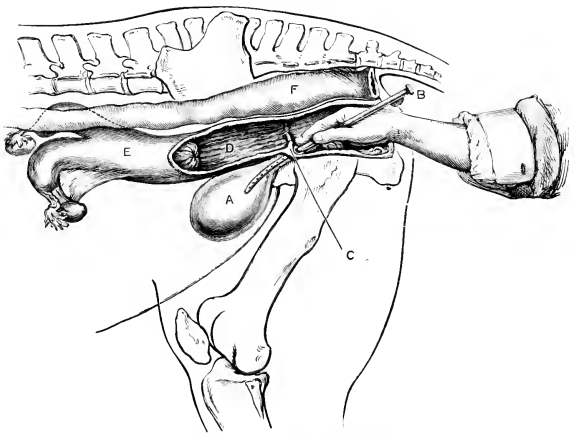


Fig. 145.—Retention of Urine in the Mare—passing the Catheter

A, Bladder. B, Catheter. C, Valve overlapping entrance to bladder. D, Vagina. E, Uterus. F, Rectum.

tioned, *inter alia*, that while some horses will almost insist upon pulling up for the purpose of passing urine, others require perfect quietude, and can only be induced to stale by taking them on to a straw bed. It is occasionally found that a horse will not relieve himself while on a journey, although taken out of a carriage, unless the bridle is removed or the breeching. The inability to pass water after compulsory retention arises out of a temporary paralysis of the muscular coat of the bladder, the result of undue stretching.

Symptoms.—Repeated but unsuccessful attempts to urinate, standing with the front and hind legs far apart, straining, grunting or groaning, and possibly the passing of a few drops of urine, which seem rather

to leak away than to be the result of effort. Rectal examination will confirm the diagnosis if any doubt or difficulty exists in determining between retention and non-secretion of urine. In the former condition the bladder can be distinctly felt to be distended with fluid, and in some cases the pressure of manipulation adds just sufficient force to expel a portion of it. In the latter the organ is more or less empty.

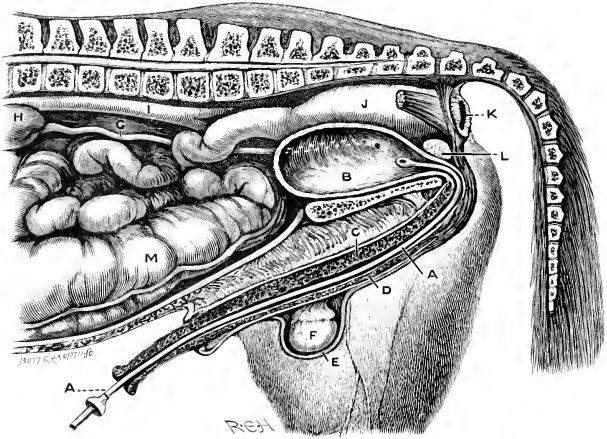


Fig. 146.—Retention of Urine—Catheter inserted

A, Catheter. B, Bladder. C, Corpus spongiosum. D, Corpus cavernosum. E, Scrotum. F, Testicle. G, Ureter. H, Kidney. I, Aorta. J, Rectum. K, Anus. L, Prostate gland. M, Colon.

Treatment.—If the urine has been long retained, and the bladder contains a large quantity, the catheter should be passed and the greater portion drawn off. Should there be indications of pain afterwards, warm fomentations to the loins, or a large poultice over that region, will have a soothing effect, and this may be increased by the admixture with it of extract of belladonna. The animal should be warmly clothed, and a dose of two or three drams of camphor dissolved in linseed-oil may be given, followed in two or three hours by one or two dram doses of extract of belladonna dissolved in linseed tea. Every inducement to urinate should be offered by placing the patient in a well-bedded loose-box undisturbed by other horses or their attendants. When retention of urine is

connected with swelling of the sheath, the latter should undergo thorough cleansing with soap and water, and be afterwards lubricated with oil or vaseline. In extreme cases scarification with a small lancet may be called for.

Incontinence of Urine.—Here there is an inability to retain urine, which is discharged involuntarily, and cannot be controlled by the patient.

Causes.—This may be due to a relaxed or paralytic condition of the muscle which guards the neck of the bladder, and ordinarily prevents the urine from passing out; it may also result from injuries, morbid growths, or the partial blocking with calculi.

Treatment.—If caused by a mechanical impediment it may sometimes be removed by the passage of a catheter into the bladder, or by the forcible injection of fluids from a syringe into the urethral canal. Where a calculus exists in the urethral passage it may require a surgical operation.

STONE IN THE BLADDER

Composition of the Urine.—At the time of its discharge the urine of the horse differs in its appearance on different occasions. In colour it varies from a pale-yellow to a deep brownish-yellow. It is usually transparent, but frequently turbid, and occasionally distinctly muddy and opaque. It has a strong, disagreeable odour and a saltish taste. When allowed to rest, a dullish gray precipitate is thrown down, consisting chiefly of calcic carbonate (fig. 134). Its reaction is alkaline, and on the addition of an acid, free effervescence is induced.

The specific gravity varies between 1·015 and 1·050. Microscopically examined, the sediment thrown down in repose is found to be made up chiefly of spherical, oval, and dumb-bell crystals of calcic carbonate, occasionally also octahedra of calcic oxalate, with a few epithelial cells from various parts of the mucous tract of the urinary apparatus.

The following two analyses given by Von Bebra show the composition of the secretion:—

	I	II
Water	885·09	912·84
Solid constituents	114·91	87·16
Urea	12·44	8·36
Hippuric acid	12·60	1·23
Uric acid	—	—
Mucus	0·05	0·06
Alcohol extract	25·50	18·26
Water extract	21·32	19·25
Soluble salts	23·40	40·00
Insoluble salts	18·80	

The sediment obtained after the fluid has been allowed to rest is shown by three analyses to consist of organic and inorganic matter in the following proportions:—

	I	II	III
Carbonate of lime ...	80·9	87·2	87·5
Carbonate of magnesia ...	12·1	7·5	8·5
Organic matter	7·0	5·3	4·3
	100·0	100·0	100·3

It will be seen from the above that urine is a highly complex fluid, comprising organic and inorganic constituents in a state of watery solution.

Origin of Stone.—On the origin of vesicular calculus there is very little of a definite nature to be advanced. It is a well-established truth that under certain local as well as general conditions of the body the renal secretion undergoes various modifications and changes both in its physical state and chemical constitution. Thus, normal constituents may be increased or diminished, or altogether disappear, while others foreign to the secretion are sometimes found entering into its composition.

These departures from the general standard are in some cases doubtless connected with physiological deviations in the complex processes of assimilation, and in some measure also with chemical alterations which the urine undergoes after its departure from the kidneys.

In diseased conditions of the system peculiar compounds are not unfrequently formed which are rarely or never produced in the healthy organism, and, being feebly soluble in urine, are immediately deposited in a solid form from that fluid. In this manner oxalate of lime comes to form a part, and in some very rare cases the whole, of the vesicular calculus in the horse.

To what extent the superabundant formation of lime-salts in the economy is referable to food, water, climate, and assimilative disturbance, separately or together, we have at present but little to guide us to a satisfactory conclusion. The fact remains, nevertheless, that some horses eliminate from their systems an amount of calcic carbonate that is simply astonishing. The writer's attention was recently called to a case in which a considerable amount of this salt was periodically removed from the bladder of a mare in addition to that which escaped with the urine in the act of micturition.

On this subject the late Professor Morton remarks: "The water drunk by animals has generally been considered as the source of calculi, but it is by no means proved that in those localities where lime is more abundantly met with in water, as Matlock, Scarborough, Carlsbad, and other limestone districts, that in these, calculous affections are most prevalent; whereas

we do know that animals kept on any of the lime plants for a long time, or pastured where lime has recently been laid, become the subjects of these accumulations. Nevertheless, excess of lime in water will readily furnish the requisite calcareous matter."

Why the salts of the urine should cease to be held in solution by the urinary secretion may be conceived to arise either out of a supersaturated condition of that fluid or from chemical reactions resulting in the production of insoluble compounds, but it is not always so easy to comprehend the reasons which in certain cases determine the aggregation of small particles of salts and the development of a distinct calculous formation or stone. Such a state of quiescence as is afforded by a paralysed bladder would appear to favour the separation and aggregation of the crystallizable constituents of the urine, as would also its retention for long periods in the cavity of the bladder, either as the result of habit or by force of stricture of the urethra, prostatic enlargement, or other like interferences with its proper and due discharge, but it cannot be said that stone in the bladder is specially prevalent under these circumstances.

Experience gives no encouragement to the idea that the tendency to stone formation is greater in proportion to the amount of stone-forming salts secreted by the kidneys.

Composition of Vesical Calculus.—The following table of analyses of vesical calculus of the horse and ass is given by Furstenberg:—

	Horse.					Ass.		
	Yellowish White.	Brown.	Brown.	White Hard	Sediment ary Form.	Yellowish White	Yellowish Brown.	White Hard
Specific gravity	2·231	2·104	2·017	2·245	2·076	2·213	1·767	2·257
Carbonate of lime ...	87·10	83·25	61·55	85·03	84·30	69·90	67·75	80·3
Carbonate of magnesia	3·63	5·73	8·97	3·62	8·34	6·75	9·93	15·5
Oxalate of lime	2·10	2·60	17·57	...	...	4·44	10·25	Trace.
Phosphate of lime ..	...	...	4·32	5·81	...	4·37	...	...
Ammonio-phosphate of magnesia	...	..	...	..	...	...	...	...
Silicic acid	...	...	...	...	...	...	...	...
Uric acid	...	...	...	...	...	...	...	...
Organic matter	5·45	6·67	5·95	4·21	5·95	12·75	10·95	2·9
Water and loss	1·72 Trace.	1·75	1·64	1·33	1·41	1·79	1·12	1·3
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·0

Calculi, it will be seen, are composed of earthy salts in combination with a greater or less amount of organic matter. As shown by reference to the above analyses, carbonate of lime constitutes over 80 per cent of

the whole. Vesical calculi in the horse are strikingly uniform in composition, and in this respect contrast greatly with similar formations in omnivorous man, in whom they are also more frequent. In him the urine contains a greater number and variety of crystallizable substances, several of which, both separately and in combination with others, assume the form of stone. Hence we have calculi of uric acid, urates of soda, ammonia, and lime, as well as others of calcic acetate, triple phosphate, and various combinations of these renal salts.

Symptoms of Stone. – The symptoms attending the existence of vesical calculus are far from uniform, either in their number, nature, or intensity. In some cases they are few, slight, and dubious, while in others they are many, pronounced, and easy of interpretation. The very slight physiological disturbance sometimes seen in stone disease has, in many instances, disarmed suspicion and frustrated detection, thus serving to sustain the prevailing idea that stone in the bladder is a disease of extreme rarity, a conclusion there is reason to think is too generally accepted by veterinary practitioners.

Vesical trouble arising out of the presence of stone is mostly exhibited, in the first instance, by frequent attempts at staling, some of which are abortive, and others more or less imperfectly and with difficulty accomplished. The urine is discharged in small quantities at brief intervals, and the completion of the act is signalized by a deep grunt indicative of pain. The desire to empty the bladder is more frequent and urgent during and after exertion, and particularly marked when the pace has been quick. Every now and again, while at work, the affected animal dwells in his movement and essays to stop. If permitted to do so, the body is at once extended, and a small quantity of urine discharged. Where the calculus is large, rough on its surface, and free to move in the cavity of the bladder, blood appears in the urine as the result of exertion. Whenever, therefore, exertion is immediately followed by the appearance of blood in the urine, the case should be regarded with suspicion, unless some other and more obvious cause is revealed. In some instances the penis is projected from the sheath, and again retracted, at short intervals, and we have seen it remain extruded in a pendulous condition during the whole period of the disease, and to return again only after the operation of lithotomy.

The discharge of urine is sometimes effected in a continuous stream, sometimes the flow is suddenly interrupted by the calculus blocking up the neck of the bladder, and occasionally it passes away involuntarily in small quantities. After the bladder has been freely emptied, the anus undergoes a repetition of spasmodic contractions. Now and again the stone becomes impacted in the neck of the bladder, or, if a small one, may escape into and

be arrested in the urethra, resulting in obstruction and over-distension of the organ, with the usual train of symptoms indicative of abdominal pain. In some examples of the disorder the gait during progression is wide and straddling, and when at rest the hind-limbs are occasionally raised from the ground as if in pain.

The diagnosis is, in the majority of cases, unattended with difficulty where proper methods of enquiry are pursued, but, as we shall presently show, the detection of stone sometimes taxes the resources of the ablest diagnostician. Tumours in the bladder, croupous cystitis, organic disease of the kidneys, and various other ailments pertaining to the urinary receptacle may, and do, occasion symptoms only distinguishable from those of calculous disorder by a careful and searching exploration of the bladder per rectum, and by catheter or sound through the urethral canal. In regard to this latter part of the enquiry it need hardly be urged that upon it the diagnosis mainly depends. Exploration of the bladder per rectum seldom fails to reveal to us any decided enlargement occurring within or without it, but the tact and discrimination of the surgeon is often sorely tried in distinguishing between a calculus and certain forms of tumour which now and again present themselves there. In searching for stone, the mind, and with it the hand, naturally turns to related organs, and, remembering the possible enlargement of the prostate gland, seeks first to determine the condition of this organ in particular whenever vesicular calculus is suspected. Tumefaction of the prostate is fortunately not difficult of recognition. The backwardness and fixed condition of the swelling, its intimate connection with the neck of the bladder, its peculiar outline of form and yielding nature, serve at once to distinguish it from stone. Tumours in the bladder usually disclose themselves by their diffuse, and maybe also by their lobulated and fixed condition.

The bladder should now be explored by means of a long sound passed through the urethra, assisted, in the case of a horse, by the hand of the examiner passed into the rectum. In searching the bladder for stone the organ is allowed to become moderately distended with urine, when, first in a standing, and then in a recumbent, posture, the sound (after being well oiled and disinfected) is introduced into the urethra, and gently forced on until it enters the bladder. It is now moved slowly backward and forward with a rotatory action, so as to bring the metal point of the instrument into contact with every part of the interior surface of the bladder, the operator noting at the same time any roughness or irregularity of surface or resistance it may meet with, or any sound or impression it may convey. If the result is not satisfactory, the position of the patient must be changed by turning the animal first on one side and then on the

other, and now on the back, until every part of the bladder has been thoroughly explored. Where the substance felt per rectum is a calculus, its contact with the searcher will be clearly made known by the rough and resisting character of the touch, and by the sound emitted when struck.

Even with the exhaustion of all the methods and devices which science has designed for surgical diagnosis, failure may still attend our efforts to detect a stone, and although the existence of something in the bladder be ever so obvious, its precise nature cannot always be clearly and definitely made out. In those examples of stone, partially or completely overgrown by granulation tissue (proud flesh) (fig. 147) springing from around an ulcerating surface, or enclosed in false membrane, the question of stone or tumour is difficult to divine. Here the stone, hidden away in the new growth or exudation matter, is sheltered from the sound, and the instrument, striking the morbid mass, imparts to the hand precisely those impressions which denote the existence of tumour. In this uncertain and unsatisfactory condition no time should be lost in opening the urethra at the perineum, when the bladder may be again explored by means of the short metal sound, to be referred to later on.

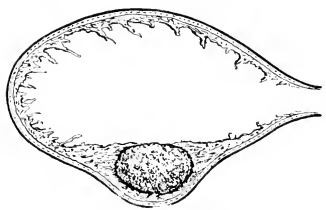


Fig. 147.—Stone Overgrown with Granulation Tissue

It is not alone by active changes in the bladder, such as I have just referred to, that stone is enabled to evade detection. Passive alterations in this organ are likewise to be borne in mind as possible obstacles in the same direction. The most familiar example of this anomalous condition is met with in those cases where the weight of the stone, bearing on the anterior end or fundus of the bladder, creates for itself a diverticulum or pouch, in which it becomes lodged (fig. 148). The mucous membrane in those instances usually constitutes the sac, it having been pushed between the widely separated and atrophied fibres of the muscular coat; less frequently all the coats enter into the saccular offshoot. In some

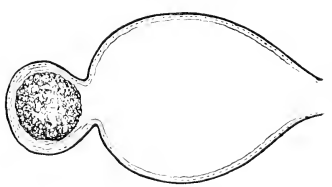


Fig. 148.—Stone Empouched in the Fundus of the Bladder

rare instances, as one recently related to me by Mr. F. Wragg of London, not only does the stone occupy the pouch, but, enlarging by accretion in the direction of the interior of the viscus, comes also to project into the proper cavity of the bladder (fig. 149). This is an important condition to consider in relation to the success of the operation of lithotomy, as will hereafter be explained. Where the stone becomes thus encysted it may or may not be accessible per rectum in a standing posture, or to the sound through the urethra, according to the extent to which it has extended from the pelvis in the direction of the abdominal cavity. If, however, the horse be placed on his back, the stone will be caused to fall towards the spine, and thus be brought within reach of the hand.

Referring again to the general symptoms of stone, it may be remarked that they undergo various modifications of character and intensity, according to the size, nature of the surface, and the relations of the calculus with the general cavity of the bladder.

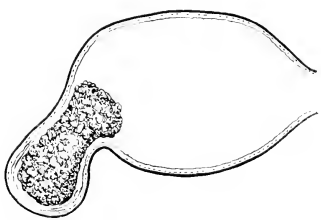


Fig. 149.—Stone Empouched in the Fundus, and extending into the Cavity of the Bladder

Stones of large dimensions occasion much pain and suffering, especially where the surface is rough and the stone free to move from place to place with the movements of the body. Here the mucous membrane suffers much irritation, and, with the muscular coat, becomes considerably thickened. As a result, the walls of the bladder lose their expanding power, and, by failing to open out for the accommodation of the incoming urine, provoke and render necessary frequent acts of micturition. Inflammation and purulent urine are among the worst consequences of a heavy rough calculus.

Smooth calculi (which are rare), and such as are confined in pouches of the mucous layer, occasion much less disturbance, and may even fail to excite suspicion of their presence.

Treatment.—Various methods, physiological, chemical, and surgical, have in turn been practised and extolled for the prevention and eradication of stone, and each succeeding decade, with its larger experience and resource, has called forth either the condemnation or modification of the one, or the improvement and consolidation of the others. For a considerable period belief and reliance in the efficacy of internal remedies was largely entertained; but as time advanced, and the teachings of anatomy,

physiology, and physics led to the improvement of surgical methods, surgical means, and surgical handicraft, the treatment of stone passed well-nigh altogether from the domain of the physician to the more practical and radical dispensation of the surgeon.

Internal Remedies.—The internal remedies which have been recommended and employed in this branch of treatment have been selected purely on the ground of their chemical properties and action on alkaline carbonates out of the body. A vesical calculus, it has been argued, consisting as it does chiefly of calcic carbonate, should be chemically resolved by the repeated administration of mineral acids, experience in the laboratory having taught that the decomposition of the former is readily and surely effected by contact with the latter; hence mineral acids were for a long time, and still continue to be, administered for the purpose of bringing about a solution of the stone. Practical experience, however, has at no time done much to confirm this time-honoured dogma, and the teachings of physiology encourage no sort of belief in its therapeutical value. Even in those instances where the operation of lithotomy is forbidden by the circumstances of the case, we are not warranted by any consideration in relying on so precarious, nay useless, a remedy as the so-called *stone solvents*.

Injection of Stone Solvents into the Bladder.—Acid solutions directly introduced into the bladder stand in a very different position to the calculus from those which, having been swallowed and having traversed the alimentary canal, now enter the blood and circulate the system in a state of extreme dilution. In the former case the solvent and the substance to be acted upon are brought immediately into contact with each other without having been exposed to any possible source of decomposition, and in this instance the two chemicals are placed under conditions which invariably yield a definite known result. On the other hand, we have no assurance whatever that the acid which enters the mouth ever reaches the bladder in an uncombined state. On the contrary, the absence of any therapeutical response to the continuance of the remedy, as well as a knowledge of the chemical reaction of the secretions (salivary, biliary, pancreatic, &c.) with which it must be brought into contact in its course towards the blood, all go to suggest its speedy neutralization and consequent inertness as a stone solvent. Clear as may be the chemical action of acids on calcic carbonate, and constant as is the composition of equine vesical calculus, there are nevertheless serious objections to the general employment of such remedies in the treatment of stone. In the first place, the strength of the solution injected into the bladder must at all times be so weak as to produce the feeblest solvent

action, or the already irritable, and perhaps eroded, mucous surface will be excited to inflame and lead to renal complications and other untoward results. To be effectual, therefore, a frequent and prolonged application of the remedy is indispensable.

The operation of injecting the bladder is clearly one which cannot be entrusted to lay hands, and if carried out to meet the necessities of the case by a qualified surgeon, must involve considerable outlay, to say nothing of the trouble, risk, and loss otherwise sustained. Obviously then the *remedia lithontriptica* becomes, for all practical purposes of stone, a dead letter, and must be relegated to the limbo of exploded fables.

The Operation of Lithotomy.—Great and important as have been the innovations and improvements in the course of the development of human surgery during the past fifty years, it must be admitted that operative measures of procedure in combating disease in the lower animals have not kept pace with the tide of progress everywhere revealed in the surgical treatment of man. Nor was it to be expected that animals, whose material services constitute their real worth, could for economic reasons be allowed those higher considerations in which everything is subordinated to the maintenance of life. Before deciding upon the operation of lithotomy a careful consideration should be given to every feature of the case, and the chances of success and failure well weighed in the balance.

In tutored hands the operation may be said to be a fairly safe and successful one under ordinary circumstances; but whoever undertakes it must be prepared to encounter deviations and difficulties, as in all operations, and should command the necessary information and experience by which they may be met and overcome.

The very brief and general terms in which this operation is described, and the summary manner in which it is dismissed by veterinary authors, are not such as to throw much light on the *modus operandi*, and no doubt it is for want of more precise and reliable information in this connection that lithotomy in the lower animals is so little understood and so seldom practised.

Preparing for the Operation.—Preparing the patient for the operation of lithotomy or lithotrity is in all cases more or less desirable. It should ever be borne in mind that the aim and object of extracting a stone is not merely the accomplishment of a surgical feat, but to preserve life, and, what is equally important from an economic point of view, the utility of the patient. Every means, therefore, tending to ensure success should be fully considered and adopted.

In entering upon the operation the bladder should be fairly distended with urine, when the horse should be cast, as for the operation of castration. The penis and sheath are now thoroughly cleansed, and all fæcal matter removed from the rectum. The administration of chloroform is

Fig. 150.—Grooved Staff

now proceeded with, and when the animal is fully under its influence the hind-quarters are raised by under-packing with straw, and the patient, having been placed on his back, is supported on either side and held steadily in position. The penis is now unsheathed, thoroughly washed and disinfected, and a well-oiled grooved staff (fig. 150) is introduced into the urethra, and pressed carefully onwards towards the bladder by an assistant, the operator guiding the course of the instrument along the perineum with the left hand, while the right, which is in the rectum, directs the point towards the bladder. By a little manœuvring the groove of the staff is brought to face the perineum, and the assistant is instructed to press the instrument toward the abdomen, and hold it steadily in position. A scalpel is then taken in the right hand, and the skin of the perineum being stretched by the left forefinger and thumb, is incised along the central line from the pubic arch to within an inch or less of the anus. The point of the knife (fig. 151) is now forced through the walls of the urethra into the groove of the staff, and an opening made according to the size of the orifice required for the passage of the stone. A bullet-headed whalebone probe (fig. 153) is now introduced into the groove, along which it is directed into the bladder.

Fig. 151.—Lithotomy Knife (sharp-pointed)

Fig. 152.—Lithotomy Knife (blunt-pointed)

Fig. 153.—Whalebone Probe

The staff is then withdrawn, and the disinfected finger, following the course of the probe, is next passed into the cavity, the probe at the same time being withdrawn.

The deeper wound, *i.e.* the urethral orifice, must now be enlarged by extending the incision along the same line through the membranous urethra. This will be effected with the least risk with the probe-pointed bistoury (fig. 152), the finger in the passage acting as guide and lever

in performing the section. In carrying out this part of the operation the knife should be well under control. This incision is made from within outwards, deliberately but with caution, always remembering that the rectum lies immediately beneath, and stands in danger of being cut. Such a result, it need hardly be pointed out, would not only seriously complicate the case, but place the animal's life in jeopardy.

Exploring the Bladder.—The urethra having been laid open as far as it is deemed requisite to admit the passage of the stone, an exploration with the finger should be made. While the left forefinger, already in the bladder, explores the neck of the organ, the right hand, acting through the rectum, will, as far as possible, force the bladder backward in order to bring a larger area of surface within reach of the finger. Here a long index finger offers a distinct advantage, and should the operator fall short in this particular, he may take advantage of such help as his most practical assistant may be able to afford him. As a rule we are only capable of manipulating the neck and parts immediately beyond it, but by means of the short metallic sound, presently to be described, we are enabled to recognize any marked alteration in the naturally smooth, satin-like surface of the lining membrane. By careful exploration we may, for example, satisfy ourselves of the existence of tumour, false membrane, calcareous encrustation of the mucous layer so often found in association with calculous disorder. A knowledge of the presence or absence of these morbid conditions constitutes a distinct advantage in estimating the immediate success of the operation and prospective result of after-treatment.

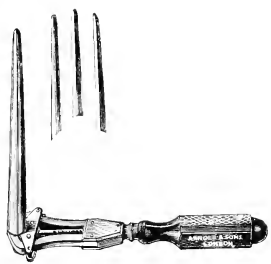


Fig. 154.—Dilator

Dilating the Urethra and Cervix Vesica.—Having devoted a few minutes to the very interesting and instructive task above referred to, we now proceed to dilate the urethra and neck of the bladder. It is a great consolation, when confronted with a large stone, to know that this portion of the urinary passage is capable of considerable relaxation and dilation. Sudden and spasmodic attempts at dilation is bad practice, and should on no account be resorted to. For effecting the opening out of the urinary channel the three-bladed dilator (fig. 154), constructed on the plan of a human anal dilator, but with longer blades and with a correspondingly large range of action, will be found effective.

This is introduced into the opening made in the perineum and pushed onward towards the bladder. The handles of the instrument are now compressed and the blades caused to diverge steadily until the necessary dilation has been accomplished.

The patient is now allowed to rest on the right side. The operator finds it most convenient to occupy the recumbent posture, and places himself on his left side.

The form of the forceps to be employed in removing the stone will, of course, depend upon the consistence of the calculus to be removed. Where the superficial portion of the stone is found to be loose in texture, and consequently liable to crumble, the spike-faced forceps (fig. 155) should be employed. This is armed with three spikes on the opposing surface of each blade, which, on meeting the stone, penetrates its outer weak crust, and gains a firm hold of the more dense parts beneath. Escape from the grip of the instrument during extraction is thus rendered difficult, and disintegration is at the same time avoided. The forceps, held in the left hand, is introduced into the bladder, and the right hand is passed into the rectum to steady and direct the stone, which will now be distinctly felt and heard grating against the instrument. Here the blades must be opened and closed again and again, with a catching movement, being also turned about first in one direction and then in another, until seizure of the calculus is effected. Should any difficulty in securing the stone be experienced in the procedure, the forceps is to be withdrawn, and the calculus brought forward by the hand acting through the rectum and held firmly against the neck of the bladder, while the blades of the instrument are slid carefully over it. A firm hold having been secured, the operator must then assure himself that no part of the mucous membrane is grasped and included with the stone. This may be done by rotating the forceps on its axis, and moving it backwards and forwards, first in one direction and then in the other. If no impediment is experienced it is to be inferred that the bladder has not been laid hold of, and that in this respect all is right; on the other hand, should the movement of the instrument meet with interruption, the blades must be slightly relaxed and the imprisoned membrane liberated. The position of the stone, as it rests in the forceps, is next to be considered.

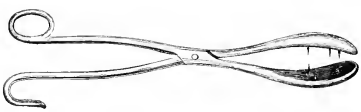
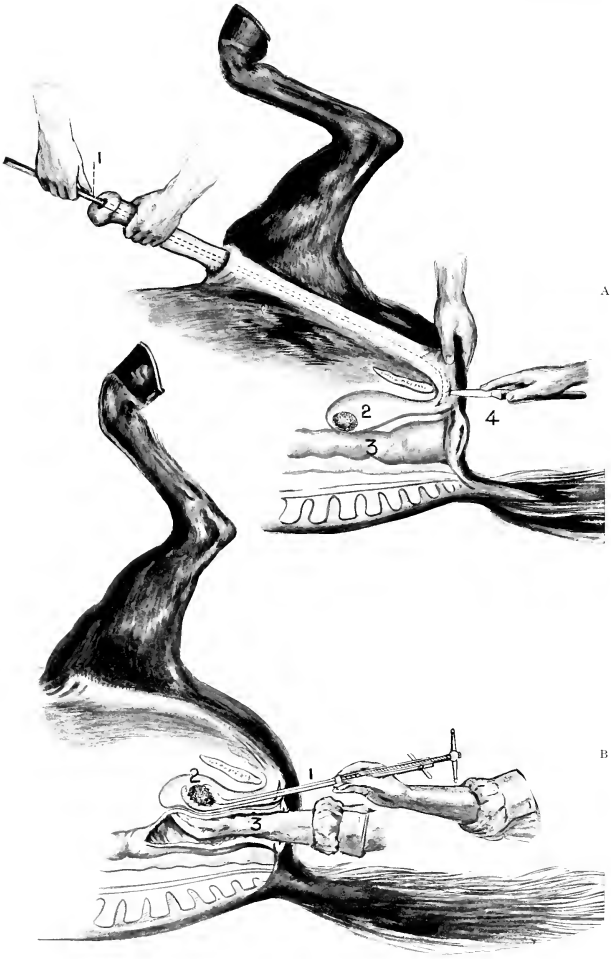


Fig. 155.—Spike-faced Forceps

Here we may remark that vesical calculi are almost invariably ovoid in shape, and are frequently seized across the short diameter, in which position



OPERATION FOR STONE

Fig. A. 1. Catheter. 2. Stone. 3. Rectum. 4. Knife cutting into the Urethra.

Fig. B. 1. Lithotrite. 2. Stone in the jaws of the Lithotrite. 3. Hand in the Rectum assisting in bringing the Stone into the jaws of the instrument ready for crushing.

it is at all times difficult, and in most instances impossible, to extract them. For this reason it is of the first importance that the long diameter of the stone should be made to correspond with the long axis of the forceps. To accomplish this the calculus is drawn well up to the neck of the bladder, when, with the index finger acting between the released blades of the instrument, it is carefully turned and brought into the desired position. This having been done, extraction of the stone is then proceeded with. The extracting force required to effect removal will, of course, depend upon the size of the stone in relation to the urethral orifice. Large calculi, and particularly such as are rough and catchy, require a considerable amount of traction and careful manœuvring to bring them away. Before attempting removal, the stone must be firmly gripped and a good hold secured by bringing both hands to bear on the handles of the forceps, whose blades should be so placed that their surfaces are directed right and left, and their edges upward and downward. A steady and continuous pull, gradually increasing in force, is now begun and continued, with a wriggling movement of the hand and an occasional slight alteration in the direction of the traction, at one time pulling slightly to the right, at another to the left, now upward, then downward, and so on. If the wound be not sufficiently large, a touch with the scalpel here and there at the points of resistance may be resorted to as a means of facilitating extraction, or an assistant may be called upon to open the wound by inserting his fingers well within its edges and pulling in opposite directions. Should the stone prove to be too large for extraction by reasonable force, crushing must be at once had recourse to. Where the calculus is loose in texture, and friable, the resistance of the edges of the wound to the extracting force may give rise to disintegration of the outer crust, which, breaking away, remains in the blades of the forceps, while the main body of the stone escapes into the bladder. In such an event the offending body must be again secured. Having undergone a reduction of size, less resistance will be experienced in the next attempt at removal. An additional advantage will also be gained in the firmer hold the more compact remains of the calculus allows to the forceps.

Having removed the stone, the bladder will now require to be well washed out with warm carbolized water in order to cleanse it of the blood, mucus, and earthy debris, some or all of which it is sure to contain in greater or less amount. This operation is best accomplished by introducing the three-bladed dilator (fig. 154) into the neck of the bladder, and, after moderately enlarging the orifice, forcing into the cavity a fairly strong stream of warm carbolized water out of a small enema syringe.

Whether the perineal wound should be closed at once must depend

upon the nature and extent of disease existing in the bladder. If there is reason to think that the lining membrane is seriously ulcerated, or covered with false membrane, a distinct advantage will be gained by introducing a lithotomy tube (fig. 156) into the bladder and allowing the wound to remain open until the vesical irritation has been subdued by frequent injections of warm carbolized water. On the other hand, if no such complications exist there, the edges of the superficial wound may be brought together at once by three interrupted sutures of flexible wire, and the patient removed to his box.

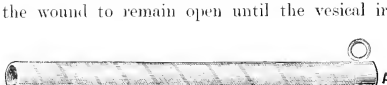


Fig. 156.—Drainage Tube

A, Silver mount and rings. B, Elastic gum tube.

The irritation resulting from the operation naturally leads to much whisking of the tail, during which hairs become entangled with the wire, and the parts about the wound suffer considerable contusion; this must be provided against by tying the tail on one side to a roller or some other convenient arrangement.

Fig. 157.—Perineal Needle

Under ordinary circumstances but little is needed in the shape of after-treatment. The skin below the perineum is smeared with lard or vaseline to prevent excoriation by the urinary and other discharges, and the wound is carefully cleansed and carbolized as often as may be required. An enema of warm water occasionally thrown into the rectum affords a good deal of comfort by freeing the gut from feculent matter, and removing all pressure from the sore and sensitive urethra and bladder beneath.

Lithotripsy.—The operation of lithotripsy or crushing may be resorted to when the stone, though too large to be moved entire, is yet small enough to be seized and broken up into fragments by means of the lithotrite. In the quadruped it is not performed as in man, through the natural channel of the urethra, but through an artificial opening in the urethral canal as described in the operation of lithotomy. It must, therefore, always be regarded as supplementary to lithotomy, and depend for its performance on our inability to extract the calculus whole.

In the absence of serious complications lithotripsy offers a fair and reasonable prospect of success.

If from the first the operation is found to be necessary, the bowels should be freely opened with an aloetic purge, and the diet so ordered as

to avoid undue fulness of the alimentary canal, and facilitate digestion. An enema of warm water administered once or twice during the twenty-four hours before its performance will serve to keep the rectum empty and soothe the irritable bladder. Small doses of potassic bicarbonate, and opiates, if necessary, may be given at intervals where pain is indicated.

The Operation.—In performing the operation of crushing, the horse is thrown as for castration, and when under the influence of chloroform the urethra is opened in precisely the same manner and place as directed for lithotomy. The neck of the bladder is then dilated, and the lithotrite (fig. 158), nicely warmed and smeared with oil, is passed into it. The blades of the instrument are then drawn as far apart as may be necessary to receive the stone. The next step is to bring the calculus fairly between them. To accomplish this the lithotrite should be held by one hand applied near the blades, the screw being in charge of an assistant who will also steady the instrument while the seizure is being effected. With the other hand in the rectum the operator now proceeds to manipulate the stone, and by a little careful manœuvring directs it into the jaws of the lithotrite. The assistant, on being instructed, will then turn the screw until the calculus is secured.

Fig. 158.—Lithotrite

Having obtained a good hold of the stone a half-turn is given to the lithotrite, first towards the right, then the left, so as to determine if any portion of the mucous membrane has been included in the grasp of the instrument. To obviate this it is usual in man to operate with the bladder distended with urine, but in the horse the fluid quickly drains away through the perineal wound, and cannot therefore be made available for keeping the walls of the organ away from the calculus.

Fig. 159.—Forceps for Lithotripsy

When the stone has been satisfactorily secured, the screw is brought again into action, and the operation of crushing proceeded with. This done, the broken fragments are freed from the lithotrite and removed with the forceps (fig. 159) and scoop (fig. 160), aided by repeated injections of warm carbolized water as directed for lithotomy.

Should the operation prove troublesome and protracted, it may be

necessary to defer completing the operation to a future day, in which case a light diet should be prescribed for a few days, say from three to seven, when the operation may be again renewed, and, if possible, carried to completion. In the meantime portions of stone may enter the perineal orifice and become arrested in it. These are to be carefully removed, and it may be necessary also to pass the catheter to discharge any debris which may have accumulated in the urethral canal. In addition to this the bladder will require to be thoroughly washed out once daily with

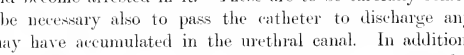


Fig. 160.—Scoop

warm carbolized water for the first two or three days, after which it may be discontinued.

On completion of the operation the bladder should be carefully searched with the short metallic sound (fig. 161), and if found free from fragments of stone it only remains to remove the animal to his box. He should then be dealt with according to the rules laid down for the after-treatment of lithotomy. An opiate draught, followed by warm fomentations to the perineum with carbolized water and periodical injections of warm water into the rectum, will serve to soothe the injured parts and allay irritation.

Fig. 161.—Sound

Vesical Calculus in the Mare.—Mares are seldom the subjects of vesical calculus. This immunity may be referred in part to the short and straight outward course of the urethra, which favours the free extrusion of solid matter with the urinary discharges.

Occasionally, however, stone is found in the female organ, but not so frequently as is generally stated. Several instances have been brought to the notice of the writer where intestinal calculi ejected from the rectum have been said to have escaped from the bladder in the act of urination. The form, character, and composition of these concretions, however, were in each case sufficiently marked to enable him to decide to the contrary. The symptoms of the affection are, for the most part, the same as those described in the horse.

Removal of vesical calculus in the mare is usually a much more simple and less dangerous matter than in the horse.

When the stone is small the operation may in some cases be performed standing. Having made the animal secure with twitch and side-line, the

neck of the bladder is carefully dilated and the lithotomy forceps introduced with one hand, while the other, in the rectum, directs the calculus between the blades. Seizure having been effected, and the manipulative precautions already prescribed duly observed, its removal is proceeded with in the manner directed.

Where it is found to be of large size, and the extraction of it by this method impracticable, the animal must be cast and placed under the influence of chloroform. By this means the sphincter vesica will be relaxed and its dilation more effectually accomplished.

Should the stone be too large to be removed entire, it may be crushed and extracted piecemeal in accordance with the rules already laid down.

A thick, pasty, yellow deposit of calcic carbonate is occasionally found in the bladder of the male and female as the result of atony or paralysis of its walls. In both instances it may be readily removed by means of the scoop, aided by forcible injections of tepid water driven through the dilated urethra.

After the whole has been evacuated, an attempt should be made to restore tone to the vesical walls by repeated injection of cold water, supplemented by the administration of nerve tonics and good living.

General Considerations on the Structure and Formation of Calculi.—Vesical calculi are usually ovoid in form, with their surfaces sometimes slightly and unequally flattened. If they have been enclosed, or partly enclosed, in a pouch or offshoot from the bladder, they may be round, oblong, irregular, or dumb-bell shaped. The majority are of a dark-brown hue; some are palish-gray, others yellowish-brown, and a few whitish-gray. All, with rare exceptions, present a rough asperous surface (fig. 162), usually more marked on one side than the other. The side on which the stone rests while in the bladder is smoother, denser, and less rounded than the other surface. In some the asperities are coarse and rounded, and impart to the stone a distinct mulberry character, but in the majority they are finer, closer set, and less prominent. In density calculi vary very considerably in different specimens, and also in different parts of the same specimen, but it is rare to find them of that flinty hardness which characterizes some examples of vesicular calculus in man. In many instances they present an open spongy texture and are distinguished by marked brittleness and want of cohesion. As a rule the

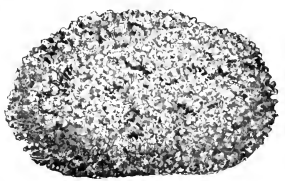


Fig. 162.—Vesical Calculus

inner portion of the stone is the more hard and compact, while the outer portion is less consistent, and, in some instances, so soft as to be readily broken down with the fingers into small rounded or angular fragments.

To examine the structure of these formations the stone should be first cut with a saw and the divided surface rubbed even and smooth on a wet stone. If the polished face be now examined it will be seen to present certain structural markings, of which the following are the more common examples:—

Fig. 163.—Section of Vesical Calculus

1. A regular series of closely-arranged concentric rings (fig. 163), representing sections of a succession of layers of earthy matter. Of these some are narrow, some broad, some yellow or pale brown, and we gather, by the use of the knife, that they are soft or hard according as they have been quickly or slowly deposited. In this variety the stone, as a whole, is usually hard and its texture compact.

2. The laminæ are irregular and incomplete, sometimes interrupted by small sinuous cavities or irregular spaces containing free earthy granules and epithelial debris.

3. Sectional surface irregular, and marked by sinuous fissures (fig. 164). Centre excavated and enclosed by a narrow strong band, from

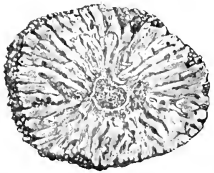


Fig. 164.—Section of Vesical Calculus

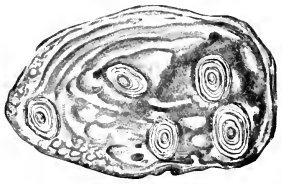
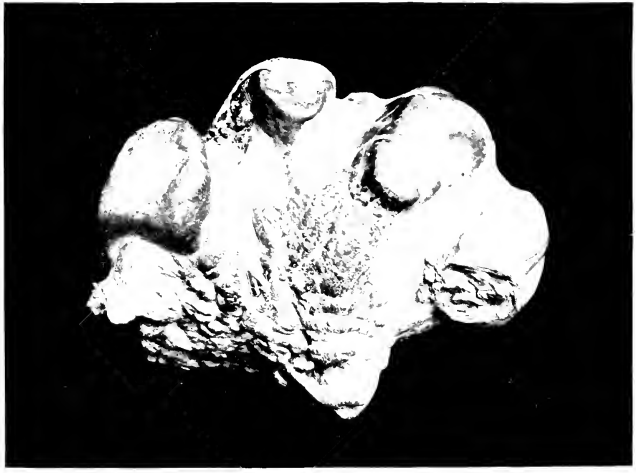


Fig. 165.—Section of Vesical Calculus

which arborescent rays proceed to the circumference and terminate in asperities on the surface, giving to the section a rough, coarse appearance.

4. Small groups of concentric rings forming rounded, solid-looking bodies varying from the size of a hemp-seed to that of a bean (fig. 165). They are separated from each other by a structureless mass of earthy matter, usually of less density than themselves, and in which fissures and cavities are sometimes met with. This variety consists of a number

Cystic Calculus having a piece of stick as a nucleus. Bladder of Horse



Renal Calculus. Kidney of Horse

CALCULI

of small laminated calculi, aggregated together and enclosed in an amorphous deposit.

All vesical calculi do not originate in the bladder. Some no doubt have their beginning in the pelvis of the kidney, in which position we have repeatedly found them in their rudimentary condition. Many of these renal formations, on reaching the bladder, are ejected with the urine, but occasionally such as acquire large dimensions are retained in the vesical cavity and undergo enlargement by earthy incrustation.

It is certain, however, that stone formation is not always the direct outcome of the conditions indicated above. Foreign substances, we are aware, sometimes find their way into the bladder of the horse, notwithstanding the seeming difficulty of such an event. Some years ago Mr. William Hunting, of London, brought to the notice of the Central Veterinary Medical Society such a case, where a piece of stick, some four or five inches in length, and as thick as the little finger, was found stretching across the bladder of a horse, with one end projecting through its walls into the pelvic cavity. It had evidently occupied this position some considerable time, as a large calculus had formed around its central portion. Whence the stick had come there was no direct evidence to show, and we are left to assume its possible introduction through the abdominal walls or through the alimentary canal. Such an accident as that first referred to is quite possible, but for many considerations does not recommend itself to our acceptance. From facts which have recently come to light in the human subject, we are more disposed to accept the explanation which refers its entrance into the bladder through the medium of the alimentary canal.

INVERSION OF THE BLADDER

The bladder of the mare may be turned inside out by spasmodic contraction of its walls, when it may be said to evert itself. The mucous membrane will then be on the outside. The accident is of very rare occurrence, and is usually brought about by the pains of parturition. It may, however, result from other causes where violent straining is excited, and the contents of the abdomen are forcibly pressed against the bladder at a time when possibly the opening into it is abnormally dilated.

Symptoms.—A fleshy-looking mass, more or less rounded, projects through the vulva, varying in appearance according as the accident is recent or of some duration; at first it is a pale pinkish-red hue, darkening with exposure to a bluish or blackish red colour. The protruding organ has been mistaken for the fœtal envelopes, and fatally injured by an

attempt to remove them. The orifices of the ureters, by which the urine enters the bladder, may be found when carefully sought on the upper and anterior part of the protruding viscus, and these will set at rest any doubt as to the nature of the tumour. When labour pains are excited, little jets of urine are seen in some instances spurting out of them from the upper part of the extruded organ (fig. 166).

Without inversion the bladder may escape through a rupture in the vaginal wall, and continue to fill with urine, which, being unable to escape through the usual channel, rapidly adds to the bulk of the tumour and to the difficulty of its replacement. The muscular layer alone of the

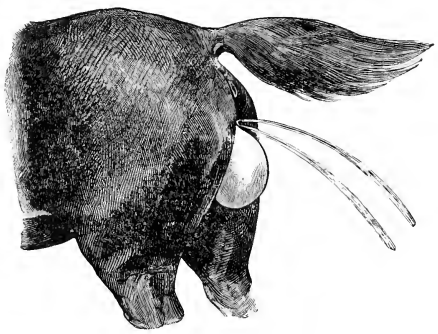


Fig. 166.—Inversion of the Bladder

vaginal wall may be ruptured, and in such case the bladder will be felt through the mucous membrane.

Treatment.—Before making any examination of the extruded organ, our hands and implements should be rendered aseptic. Having dressed the bladder, we proceed with gentle but continuous force to push it back into the vagina, seeking there for the meatus upon the floor of the passage, and gradually directing it into place with the fingers or by means of the smooth rounded end of a short stick, which should be first freely dressed with carbolized oil.

The congestion and tumefaction which result from long exposure render the task of replacement more difficult, and the greatest caution will be required in manipulating the viscus lest the swollen and softened mucous membrane be torn. It may be needful to reduce the congestion by the application of warm flannels before reposition is attempted. The

restlessness of the patient and forceful labour pains are the chief obstacles to a return of the viscus, and some restraint must be exercised to suppress them. The use of cocaine in a four per cent solution has been found helpful in producing more or less local anæsthesia, and removing the disposition to renewed expulsive efforts which the presence of the operator's hand induces.

Subsequent treatment consists in keeping the animal on soft diet and under good hygienic conditions, and the administration of anodyne medicines if pain is experienced. If a subject of this accident is again bred from, increased risk attends parturition.

4. THE NERVOUS SYSTEM

The possession of a nervous system is not essential to life, since in the whole vegetable kingdom, as well as in the lower animal organizations, multitudes of living forms are to be seen, which, although unprovided with nerves, are yet perfectly capable of preserving their independence and of holding their own in the struggle for existence; but wherever it is found, owing to its wonderful sensitiveness to impressions, it fulfils the important purposes of bringing the animal into relation with the outer world, of enabling it to respond to those impressions by inducing muscular movements which effect either local or general change of place or form, and finally of linking together, as with a subtle net-work, the most remote organs of the body, enabling each part to co-operate with the rest for the general good, and uniting or integrating them into a common whole.

Originally the nervous system is composed of a soft living mobile substance, termed "protoplasm", from which all parts of the body are formed; and it is only by degrees that it acquires its special endowment, that of generating nerve energy, which, like other forms of force, is subject to laws of its own, and can either be stored up, liberated, intensified, or exhausted under appropriate conditions.

In the horse, as in all the higher animals, the nervous system presents two parts for examination, one of which, and by far the larger, is named the cerebro-spinal, the other the sympathetic system.

The **cerebro-spinal system** is adapted to respond to various kinds of impressions made upon the organs of sense, as the eye, ear, skin, tongue, and nose, to conduct those impressions through cords, which are termed nerves, to central organs represented by the spinal cord, medulla oblon-

gata, cerebellum, and brain, giving rise in the first instance to responsive movements of protection or defence, and then successively, as they affect higher and higher centres, to sensations of sight, hearing, touch, taste, and smell, and finally to ideas, emotions, and intellectual operations.

The sensory impressions or stimuli thus carried to the nerve centres may not be followed by any visible effect, but in most instances, especially in animals, impulses, which we may conceive to be waves or rapidly-propagated chemical or molecular changes, start, or are liberated from the centres, which travel along similarly constituted cords or nerves, and are conducted to muscles or to glands, exciting the former to contraction and the latter to secretion. The cords conducting impressions from the organs of sense to the centres are named "afferent" nerves, whilst those which transmit impulses from the centres to the muscles and glands are termed "efferent" nerves. The terms "sensory", "motor", and "secretory" nerves are, however, most commonly used.

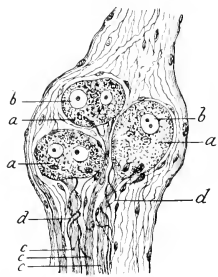


Fig. 167.—Ganglion Cells of the Sympathetic Nerve of the Muscular Coat of the Bladder (magnified about 350 times)

a, *a*, *a*, Ganglion Cells. *b*, *b*, Their Nuclei. *c*, *c*, *c*, Axis Fibres. *d*, *d*, Spiral Fibres.

The **sympathetic system** of nerves, sometimes named the nervous system of organic life, is destined to regulate the supply of blood to each organ of the body in accordance with its requirements, keeping the blood-vessels contracted when the organ is at rest, but permitting them to dilate under the influence of other nerves when in it is the active discharge of its functions. Thus in the fasting state the stomach is pale and quiescent, but in full digestion it is rosy, and performs active movements. The sympathetic system thus, by its action on the vascular system, indirectly but powerfully influences movement and secretion. It is composed of a series of knots or swellings, termed "ganglia", united to one another by nerve cords. The more important ganglia form a chain lying on either side of the spinal column, and extending through nearly its whole length (fig. 168). Other ganglia belonging to this system, termed "collateral ganglia", are widely distributed in the body, and give off branches which accompany the blood-vessels, and finally enter the muscular tissue in their walls. The two systems of cerebro-spinal and sympathetic nerves have intimate relations with each other. Their structure is very similar.

The sympathetic system consists of numerous nerve cords and ganglia distributed over the body, and destined to control and regulate the organs

of vegetative life. The main trunks of this system are two in number, one running on either side of the vertebral column, extending from the head backward as far as the tail.

Each in its course has upon it a number of small round or ovoid bodies termed ganglia. These consist of a covering of connective tissue, from which small septa pass into the interior. The spaces thus formed in the organs are filled in with small cells, some of which are round, while others have proceeding from them small fibres or poles, by which

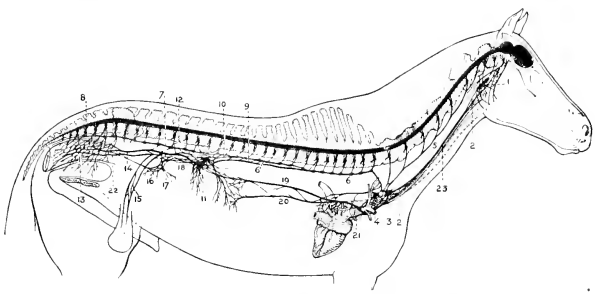


Fig. 168.—Diagram of the Ganglia of the Sympathetic System of Nerves

[1] Superior Cervical Ganglion. [2, 2] Cervical Sympathetic Cord. [3] Middle Cervical Ganglion. [4] Inferior Cervical Ganglion. [5] Cervical Portion of Sympathetic. [6, 6] Dorsal Sympathetic. [7] Lumbar Portion of Sympathetic. [8] Sacral Portion of Sympathetic. [9] Great Splanchnic Nerve. [10] Lesser Splanchnic Nerve. [11] Solar Ganglion. [12] Afferent Branches from Spinal Pairs. [13] Pelvic Plexus. [14] Branch to Pelvic Plexus. [15] Spermatic Plexus. [16] Posterior Mesenteric Plexus. [17] Branches from Posterior to Anterior Mesenteric Plexus. [18] Lumbo-Aortic Plexus. [19] Superior Œsophageal Branch. [20] Inferior Œsophageal Branch. [21] Cardiac Nerves. [22] Branch to Pelvic Plexus. [23] Conjoined Cord of Pneumogastric and Sympathetic Nerves.

they are connected with nerve-tubes, which go to (afferent) and come from the ganglia (efferent). Some nerve-fibres also pass through the ganglia, and in doing so are brought into contact with the cells.

As the sympathetic chain runs along the side of the vertebræ, a small ganglion appears upon it, opposite to each intervertebral gap or hole, out of which the spinal nerves emerge.

The spinal nerves on passing out of the spinal canal divide into an upper and a lower branch, and from each of the latter a few fibres proceed to the sympathetic ganglia and reinforce the sympathetic chain.

The different parts of the sympathetic cord are distinguished by terms indicating the region with which they are connected, hence the terms cervical or neck, the dorsal or back, the lumbar or loin, and the sacral or croup plexuses or nerves.

Cervical Sympathetic.—The cervical sympathetic consists of two large ganglia united by an intervening cord. The ganglia are distinguished as the superior and the inferior cervical. Sometimes there are three. The superior cervical ganglion, situated beneath the atlas, gives branches to those nerves in its vicinity — the glosso-pharyngeal, spinal accessory, pneumogastric and hypoglossal, and the lower branch of the first cervical nerve.

The efferent branches, or those which pass from the ganglion, are filaments to the internal carotid artery, others to the three divisions of the common carotid, and to the guttural pouch and pharynx. The branches which accompany the internal carotid into the cranium form the carotid and cavernous plexuses, and are connected with the fifth cranial nerve.

The sympathetic cervical cord passes down the neck in company with the pneumogastric, which it leaves on entering the chest and joins the inferior cervical ganglion. In its course down the neck no filaments are received or given off by it.

The Inferior Cervical Ganglion.—As we have already pointed out, this is sometimes double, the two being joined together by a short grayish band. When this condition exists, the portion in front, which is always the smaller, is known as the middle cervical ganglion.

The afferent branches, or those which go to the ganglion, are two in number, one resulting from the union of small filaments from the second, third, fourth, fifth, sixth, and seventh pairs of cervical nerves, and the other derived from the eighth cervical nerve.

The efferent branches of the inferior cervical ganglion are mainly distributed to the heart. Some very fine filaments may also be seen to enter the anterior mediastinum, or proceed to the branches of the brachial trunk.

The Dorsal Sympathetic Chain.—When the inferior cervical ganglion has given branches to the heart, the dorsal sympathetic chain is continued on from it in a backward direction, between the costo-vertebral articulation and the pleura.

As it passes backwards there appears upon it a number of very small ganglia, one of which is situated against each of the vertebral openings through which pass the spinal nerves.

Each ganglion receives one or two small afferent filaments from the inferior branches of those nerves.

In its course backwards it gives off the great splanchnic nerve at a point corresponding to the seventh intercostal space. From this point it proceeds backwards, and in its course receives a small branch from each of the ganglia.

It then proceeds to the side of the aorta between the cæliac axis and the large mesenteric artery, where it has upon it the semilunar or solar ganglion. This is a body of considerable size and importance. It is joined to its fellow on the opposite side by a large wide branch and numerous smaller ones, resulting in the formation of a plexus beneath the aorta termed the *solar plexus*.

After receiving some branches from the pneumogastric nerve, this plexus splits up into several smaller plexuses, which form a net-work round the arteries, and through them the sympathetic is distributed to the several abdominal organs. In this way we get the gastric plexus to the stomach, the hepatic plexus to the liver, duodenum, pylorus, and pancreas, a splenic plexus to the spleen, and also a plexus to the stomach. A large plexus, the anterior mesenteric, surrounds the artery of that name, and is distributed over the organs supplied by it. A renal plexus encircles the renal artery and accompanies it to the kidney.

The lumbo-aortic plexus passes backward along the under surface of the aorta, and mixes its fibres with the posterior mesenteric plexus.

The **great splanchnic nerve** leaves the dorsal chain about the seventh intercostal space. From this point it receives a few afferent fibres from the ganglia, commencing with the sixth, and continues to do so irregularly up to the sixteenth. Behind, the great splanchnic ends in the solar plexus.

The **lesser splanchnic nerve** is made up of two or three small branches proceeding from the last dorsal ganglion; these collect into a short thin branch, which joins the solar plexus or the renal and suprarenal plexuses.

Lumbar Sympathetic.—This is a continuation of the dorsal sympathetic, and has upon it ganglia corresponding to the number of lumbar nerves from the inferior division of which it receives its afferent branches. Behind, it is continued by the sacral sympathetic.

Its efferent branches consist of short filaments to the lumbo-aortic plexus. The small mesenteric artery receives others, which surround the vessel and form the posterior mesenteric plexus, in the centre of which is a ganglion of some size. This ganglion supplies in addition branches to the posterior mesenteric vein, and others to the spermatic arteries and the rectum.

Two or three long divisions from each side pass beneath the peritoneum, and on reaching the lateral part of the rectum blend with others from the inferior sacral nerves, forming the plexus from which all the pelvic organs are supplied.

Sacral Sympathetic.—This region is supplied by a continuation

backwards of the lumbar division. It presents four long ganglia, which communicate with the inferior sacral nerves by a few small filaments.

This plexus distributes its branches to the coccygeal artery, and in a somewhat irregular manner to other neighbouring parts.

Structure of the Cerebro-spinal Nervous System.—If a fragment of the brain or spinal cord be examined with the unassisted eye, it appears to be composed of a soft curd-like material with red points and streaks distributed irregularly through it, differing a little in colour in different parts, being here almost pure white and there pinkish gray, but everywhere so soft and apparently destitute of structure, that Haller, one of the most learned and expert physiologists of the eighteenth century, could only describe it as a uniform pulp with but few indications of structure, presenting only blood-vessels and some obscure fibrous markings. The great improvements that have been made in the construction of the microscope, and in the process of hardening, cutting, staining, and mounting specimens for microscopic examination, now enable it to be shown that whilst there is an abundant supply of blood circulating through each part, the essential elements of every nervous system are *nerve-cells* and *nerve-fibres*, both of which require careful consideration.

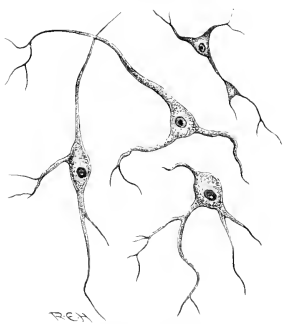


Fig. 169.—Nerve-Cells

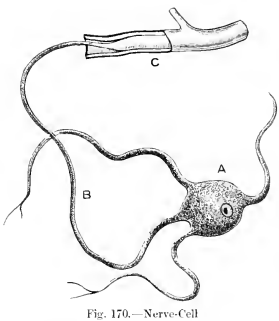


Fig. 170.—Nerve-Cell

A, Nerve-Cell. B, Axis-Cylinder Process, uniting with C, a Nerve.

The Nerve-cells.—The nerve-cells are bodies of rounded, oval, or irregular form, varying greatly in size, but always microscopic, and having an average diameter of about 1-2000th of an inch. Each cell contains in its interior a small but important structure, named the "nucleus", lying in a mass of finely fibrillated protoplasm, and itself containing a still

smaller particle, named the "nucleolus". The surface of the nerve-cell is sometimes smooth, and gives off one or two fine filamentous processes; in some instances, however, many such processes shoot from it. These divide and subdivide as they recede from the cell, and either join with or enter into very close relation with the processes from other cells. In most, if not in all cases, one of the processes is larger and longer than the rest. If traced for some distance it may be seen to become a true nerve-fibre, which may terminate in a muscle or in a gland, or in one of the organs of sense—ear, eye, nose, &c.—or may serve to bring two nerve-cells into connection with each other.

The Nerve-fibres.—Nerve-fibres are processes or outrunners from the cells. At the point where a fibre springs from a cell it is exceedingly fragile and delicate, but as it travels away from the cell it gradually acquires a protective covering or sheath, which calls to mind that employed to insulate a telegraph wire. It loses it, however, again as it approximates its destination, becoming reduced to a very attenuated thread. If examined in the middle of its course, say, for example, in the sciatic nerve, each fibre will be found to consist of a central core or axis cylinder, believed to be the path along which all nervous impressions and impulses are propagated. Covering this is a layer of white substance of a fatty nature, named the medullary sheath, or white substance of Schwann, and outside this again is a delicate but firm and resistant membrane, which is the neurilemma; such nerve-fibres are named "medullated fibres". The central core or cylinder axis often runs for long distances without division, but at times gives off collateral branches, and may even divide into a set of branches like a bouquet. Medullated fibres vary in diameter from 1-1500th to 1-12,000th of an inch. The fibres are bound together into bundles by connective tissue, and these bundles are associated into groups, the whole having a strong investment of connective tissue and constituting a nerve.

Fig. 171.—Section of Nerve

A, Nerve-Fibre.
B, Medullary Sheath.
C, Neurilemma.

The results of injury to the central parts of the nervous system are so disastrous that they are everywhere protected from mechanical violence with the greatest care. The spinal cord, cerebellum, and brain are contained in a strong case of bone particularly well adapted to preserve these soft parts from blows or pressure. The head bones are composed of an outer and an inner layer of compact bone, between which is a layer of loose cancellous or spongy bone, the whole requiring great force to cause fracture, whilst the solid bodies and projecting spines of the backbone, together with the successive layers of thick skin, fibrous tissue, and muscles

that cover it, are equally competent to protect the spinal cord. The skull will not indeed resist the penetrating power of a bullet, nor will the spine resist the weight and shock of a heavy rider in leaping into a ravine, but they will preserve the nerve centres intact through all the ordinary casualties of life. The bones are not the only means of guarding these parts from injury, for the osseous case is lined by a thick and extremely tough membrane, the *dura mater*, thin sheets of which dip down between the two hemispheres of the cerebrum, and between the cerebrum and cerebellum, and prevent the former from unduly pressing upon the latter. Within the dura mater is a thin double membrane, named the *arachnoid*, one part covering the inside of the dura mater and the other the outer part of the brain. These two opposed surfaces are lubricated with a serous fluid, which permits a slight gliding movement of the brain, such as accompanies the act of breathing and the beating of the arteries, with the least possible friction. And lastly, the whole surface of the brain is immediately invested with the *pia mater*, which is a membrane of blood-vessels, the branches being so numerous and so closely arranged in it that it may almost be said the great nerve centres rest in every position of the body on a fluid bed.

The nerve centres and the nerves receive an abundant supply of blood. The branches of the internal carotid artery and those of the vertebral arteries are distributed to the brain and cerebellum, whilst the spinal cord receives blood-vessels from the vertebral arteries, which run down the upper and lower surfaces of the cord as the spinal arteries, and are reinforced as they descend by many branches from the intercostals and posterior aorta. The blood thus distributed is returned from the head and spine by the jugular and spinal veins. The nerves of the trunk and extremities receive their blood from the nearest artery, and return it to the nearest vein.

The Spinal Cord.—The spinal cord or spinal marrow is a long, nearly cylindrical mass of nerve substance which extends from the head to the sacral region of the spine, and weighs about 10 ozs. It is contained in a canal formed by the successive vertebræ, which is wider than itself, so that there is no danger of any pressure being exerted upon it in the various movements the body is capable of performing. It has the same coverings as the brain, which are named dura mater, arachnoid, and pia mater. In front the cord enlarges both in breadth and thickness, and is continuous with the brain through the medulla oblongata. Behind it terminates near the anterior third of the sacral region. It does not preserve the same diameter from one end to the other, but presents two

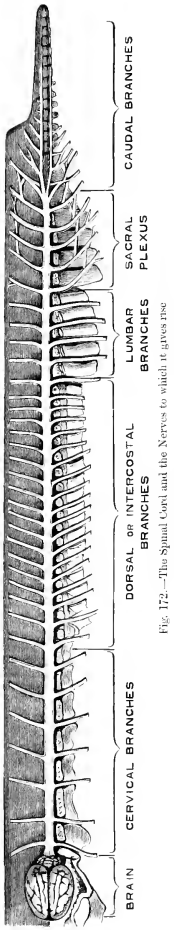


Fig. 172.—The Spinal Cord and the Nerves to which it gives rise

swellings, one extending from the fifth vertebra of the neck to the fourth vertebra of the back, and the other situated in the region of the loins. These enlargements of the nervous mass are rendered necessary in order to supply the great nerves distributed to the fore and hind limbs respectively. The spinal cord gives origin in the horse to forty-two or forty-three pairs of nerves, each of which arises by two roots, a superior and an inferior.

The position and arrangement of the successive pairs are shown in the accompanying diagram.

If the cord be divided transversely the appearance presented in fig. 173 will be seen.

The shaded area is named the gray substance, the light area the white substance, of the cord. The white substance is composed almost exclusively of nerve-fibres; the gray substance, whilst containing many fibres, presents also a large number of nerve-cells. The cord is seen to be divided into symmetrical lateral halves by two fissures, the superior fissure being narrow and deep, and the inferior wide and more shallow. The gray substance of the cord somewhat resembles the letter H, or a pair of inverted commas, placed back to back and united by a cross bar. The extremities

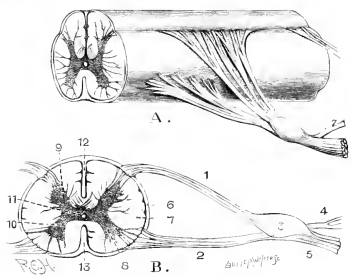


Fig. 173.—Sections of Spinal Cord

[1] Superior Root. [2] Inferior Root. [3] Ganglion. [4] Superior Nerve. [5] Inferior Nerve. [6] Choroid Plexus. [7] Nerve Substance. [8, 10] Inferior Cornua. [9] Superior Cornu. [11] Central Canal. [12] Superior Longitudinal Fissure. [13] Inferior Longitudinal Fissure.

of the comma-like bodies are named the *cornu*, and there are consequently an upper and a lower cornu on each side. The upper one is more pointed, and reaches nearer to the surface than the lower cornu. The isthmus or central portion, which joins the two lateral masses of gray substance, is perforated by a small hole, which represents the section of a tube, named the *central canal*, which runs the whole length of the cord. If the nerve roots be traced into the substance of the cord, it will be found that the fibres of which they are composed chiefly end in branches surrounding the nerve-cells of the superior and inferior cornu of their own side, whilst some ascend towards the brain on that side, and others cross over to the opposite side. Each half of the white substance of the cord is obviously divided into three regions: 1, an upper, between the superior cornu and the superior median fissure; 2, a lateral, between the upper and lower cornu; and 3, a lower region, between the inferior cornu and the inferior median fissure.

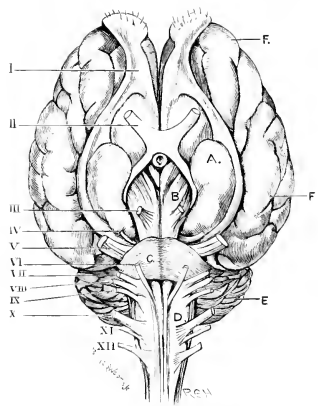


Fig. 174.—Under Surface of Horse's Brain

A, Temporal Lobe. B, Crura Cerebri. C, Pons Varolii. D, Medulla Oblongata. E, Cerebellum. F, F, Convolutions of Cerebrum. I, Olfactory Nerve or 1st Nerve. II, Optic Nerve or 2nd Nerve. III, Motores Oculorum or 3rd Nerve. IV, Pathetici or 4th Nerve. V, Trifacial or 5th Nerve. VI, Abducent Nerve. VII, Facial or 7th Nerve. VIII, Auditory or 8th Nerve. IX, Glossopharyngeal or 9th Nerve. X, Pneumogastric or 10th Nerve. XI, Spinal Accessory or 11th Nerve. XII, Hypoglossal or 12th Nerve.

In some instances the fibres constituting these divisions conduct impressions forwards, in others backwards. Some are chiefly made up of sensory nerves, whilst others are essentially motor. Others again are mixed, and convey impulses both upwards to the medulla oblongata, cerebrum, and cerebellum, and downwards from these centres to the muscles.

The Bulb, or Medulla Oblongata.—This portion of the nervous system (D, fig. 174) occupies a position intermediate between the spinal cord and the pons (C, fig. 174), and is continuous with both. It forms a kind of capital to the cord, and possesses a highly intricate structure.

It is the seat of origin of some of the most important nerves in the body, particularly of those which confer sensibility upon the face and

head, which perceive sounds, and which are instrumental in carrying on the function of breathing, and as these last are essential to life, destruction of the medulla oblongata is immediately fatal.

The Pons (c, fig. 174) is a broad and thick band of transverse fibres running across from one hemisphere of the cerebellum to the other. It is traversed by the continuation of the columns of the spinal cord. These emerge from the front border of the pons, and form the diverging crura cerebri (B, fig. 174), the fibres of which radiate outwards to the cortex of the brain. Effusions of blood affecting these columns cause paralysis.

Above the pons are the four eminences named the corpora quadrigemina, which are intimately connected with the function of sight, and are seen in section just above N in fig. 176.

We now reach the great ganglionic masses situated at the base of the brain, shown in fig. 175.

These are large, and composed of gray substance, and therefore contain many cells, in which it is probable many of the nerve-fibres in the crura cerebri end, whilst on the other hand they are brought into relation with the cortex of the brain by radiating fibres. The hinder pair are the optic thalami, and are closely connected with the optic tracts. The front pair are the corpora striata, so termed because the gray substance is traversed by bands of white fibres. These great ganglia are connected by transverse fibres forming the gray and white commissures, and the rest of their opposed surfaces form the lateral boundaries of the third ventricle.

The Brain.—The large mass of nervous substance which fills the cavity of the cranium or skull, to which the term brain is ordinarily applied, in reality consists of two parts—the cerebrum or brain proper, and the cerebellum or little brain, the proportion of these organs to each other by weight being about as 7 : 1. Both together weigh in the horse about one pound and a half, which, as compared with the weight of the body, is about as 1 : 600, or about 26 grains for each 1 lb. av. of body weight.

The *Cerebrum*, or brain proper, is divided by a deep fissure running from before backwards into two lateral halves. It consists of an immense but thin sheet of gray nerve substance externally, chiefly composed of nerve-cells, and internally of a mass of white substance composed of fibres proceeding from, or running to, the cells of the gray substance. Externally the brain is covered by three protective membranes, as well as by the bones of the skull and skin. These three membranes are the *pia mater*, which is closely attached to the brain, and is composed

principally of blood-vessels; the *arachnoid*, which is a serous membrane, and is next outwardly placed; and the *dura mater*, which is a tough fibrous membrane, and lines the interior of the skull.

The outer layer of gray nerve substance being very much larger than the surface of the brain, is folded, and, as it were, crumpled, and made to dip down some distance into the organ. The folds are named *convolutions* (fig. 175 A), and the depressions or grooves between them *sulci* (fig. 175 B).

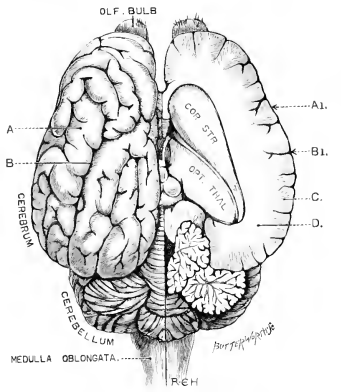


Fig. 175.—Upper Surface and Horizontal Section of the Brain

A, A1, Convolutions. B, B1, Sulci. C, Gray Matter. D, White Matter. COR. STR., Corpus Striatum. OPT. THAL., Optic Thalamus.

The convolutions appear at first sight to be quite irregularly disposed, nor will their arrangement be found exactly the same in any two brains; yet by tracing their development, and by observing the effects of injuries, a general similarity has been demonstrated in their position, and the function of each has become pretty well known.

If the brain be sliced horizontally a little below the level of the corpus callosum, a cavity is opened on each side named the *lateral ventricle*. These two ventricles are separated by the septum lucidum, but communicate with each other anteriorly, and with the *third ventricle* by the *foramen of Monro*. The floor of each lateral ventricle is formed by the corpus striatum in front, and the optic thalamus behind, and upon these lie numerous blood-vessels forming the velum interpositum and choroid plexus. The third ventricle is situated between the two corpora striata and optic thalami, and is crossed by a gray and two white commissures. Behind, it ends in the *aqueductus sylvii*, which is a tunnel running underneath the corpora quadrigemina and pons, and opening behind into the fourth ventricle, which is again continuous with the central canal of the spinal cord.

The cerebellum is situated behind the brain and above the medulla oblongata. Its convolutions are more numerous than those of the brain, but present the same crumpled disposition of the gray and white sub-

stance, the gray forming the external layer and the white the internal. The tree-like appearance presented when the cerebellum is cut in half has been termed the *arbor vitæ*.

The cerebellum is divided into two hemispheres, and a central portion named the vermiform process. At its base the white fibres forming its fibrous substance are gathered together into three great strands, groups, or peduncles, on each side; the lowest or most posterior connects it with the lateral columns of the spinal cord. The middle group forms a great part of the pons, and crosses to the opposite hemisphere, while the third group runs forward to the cerebrum.

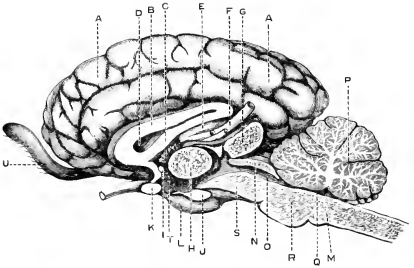


Fig. 176.—Longitudinal Section of the Brain

A, Cerebral Convolutions. B, Section of the Corpus Callosum. C, Section of the Fornix. D, Septum Lucidum. E, Internal Extremity of the Hippocampus. F, Vena Plena conveying Blood from the Choroid Plexus and Velum Interpositum. G, Pineal Gland divided. H, Gray Commissure. I, Anterior White Commissure. J, Corpus Albicans divided. K, Section of Optic Chiasma or Optic Decussation. L, Pituitary Gland. M, Medulla Oblongata in Section. N, Valve of Vieussens in Section. O, Aqueduct of Sylvius. P, Section of Cerebellum. Q, Fourth Ventricle. R, Section of Pons Varolii. S, Section of Crura Cerebri. T, Foramen of Monro. U, Olfactory Lobule from whence spring the Olfactory Nerves.

We have seen that forty-two or forty-three pairs of nerves arise from the spinal cord. Twelve more pairs arise from the brain and parts within the cranium, and are termed *cerebral nerves*. From the importance of the parts the latter supply they have received distinctive names, and appear in the following order:—1. Olfactory, or nerve of smell. 2. Optic, nerve of sight. 3. Motores oculi, nerve of motion to the muscles of the eye. 4. Pathetici, distributed to the superior oblique muscle of the eye. 5. Sensory motor nerve, supplying the skin of the head and face with sensation, and the muscles of mastication with motor nerves. 6. Abducentes, supplying the external rectus or straight muscle of the eye. 7. Facial, supplying the muscles of expression in the face. 8. Auditory, the nerves of hearing. 9. The glosso-pharyngeal, supplying the nerves of taste and some of the muscles ministering to the act of swallowing. 10. The vagus, which supplies the pharynx and larynx, the trachea and œsophagus, the lungs and heart, and the liver and other viscera with fibres, some of which are motor, while others are sensory. 11. Spinal

accessory, supplying some of the muscles of the neck and shoulder. 12. The hypoglossal, supplying the muscles of the tongue.

The Functions of the Nervous System.—Having thus acquired some knowledge of the anatomical and microscopical characters of the nervous system, we may proceed to consider the purposes it fulfils in the body. Of the two constituents of the nervous system, cells and fibres, the cells are regarded as the organs by means of which impressions are perceived and registered, and impulses to motion or secretion generated, whilst the fibres are mere conductors extending between the cells and the particular tissues to which the nerve-fibres issuing from the cells are distributed. Those nerves which conduct impressions from one or other of the organs of sense—eye, ear, mouth, nose, skin, &c.—to the spinal cord or brain are called sensory or afferent fibres. Those which conduct impulses from the cord or brain to the muscles or glands are named "efferent" or "motor" nerves. The rapidity with which the conduction of impressions or impulses is effected is very considerable. It is obvious that if the knowledge of the proximity of food or of danger, communicated by the senses, which are the outposts of the nervous system, is to prove of service, it is necessary that the information should be both accurate and prompt. The accuracy is provided for by the special attributes of the several senses. By daylight, the eye affords most of the information required, though in the majority of animals the ears are constantly on the alert against the approach of an invidious foe. At night the faculties of hearing and smell are those which are specially exercised, and in many predatory animals their acuteness rises to a height of which we can form but a faint idea.

By whichever of the senses the impressions are conveyed to the cells of the central nervous system, it is important that the muscular responses should be effected with promptitude.

At first sight it might appear impossible to acquire any definite knowledge of the swiftness with which sensory impressions of objects affecting the animal, and the motor impulses by which it responds to them, are propagated. The speed of thought is proverbial, yet by the application of electrical currents, the rapidity of which may be regarded as covering short distances and intervals with no appreciable loss of time, conclusions have been arrived at showing that nervous changes, currents or waves, travel at a much slower speed than the electric current.

It has been ascertained that nervous impulses, whether in an afferent or in an efferent nerve, that is, whether sensory or motor, in animals as different as a frog and a horse or man, travel at the rate of about

a hundred feet per second, or nearly at the rate of twenty-two miles per hour.

The most careful researches into the elements which enter into the chemical composition of nerve tissue afford no insight into the extraordinary properties it possesses. In the living state it may be regarded as a kind or form of protoplasm, but when dead and submitted to analysis it only presents those elements with which we are familiar in the proteids —carbon, hydrogen, oxygen, nitrogen, sulphur, and phosphorus, with salts of calcium, sodium, potassium, and magnesium. Complex substances known as protagon and neurokeratin may be obtained by analysis, but these are but the *caput mortuum* of the active, living, sentient material, which receives impressions, retains and reproduces them, and can liberate impulses. We are yet far from being able to predict function from chemical composition or molecular arrangement. It is interesting to notice that the gray substance of the cord and brain, which by common consent is acknowledged to be the active part, contains no less than from eighty-five to ninety per cent of water, whilst the white part, chiefly composed of fibres, contains only about seventy per cent. The reaction of nervous tissue is alkaline to test-paper.

Speaking generally, three parts are recognizable in every nerve-fibre: the origin, which is usually from a cell in one of the nerve centres; the course, which is longer or shorter in correspondence with the part of the body supplied; and the termination, which presents special modifications, in accordance with the special organ of sense to which the nerve is distributed, if it be a sensory nerve, or the muscle or gland, if it be a motor nerve.

The agent exciting a nerve to action is named a *stimulus*. Some stimuli, as electricity and mechanical irritation, seem to be able to excite all nerves to action, but, as a rule, each nerve responds, or responds best, to its own proper stimulus. Thus the undulations of light excite specifically the nerve terminations in the retina of the eye, the vibrations of sound those in the ear. The change, or information of the change, exciting the nerve endings, say, from blue to red in the case of light, is propagated along the nerve-fibre till it reaches a special sensory cell in the nerve centre. The cell, if well-nourished and not already exhausted, is excited, and a wave of force is liberated from it which may be propagated to a neighbouring cell, and may expand itself through it in producing ideas, or movement, or secretion. The stimuli with which we are most familiar, besides those of electricity, light, and sound already mentioned, are those of contact or of a mechanical nature, those of a chemical nature, as odours and tastes, those of temperature, and those

proceeding from the exercise of the will. The last always originate within the nerve centre, and the impulses they awaken travel from that centre and expend themselves on muscles or glands. It is possible that some animals may have nerves capable of responding to stimuli of which we have no more conception than a man born blind has of light, as they certainly have nerves which recognize variations in the intensity of ordinary stimuli that are imperceptible to us. Thus the presence of water, or the proximity of one of their own species, is recognized by many animals when quite imperceptible to man. A stimulus may be so feeble that it fails to be propagated to the central nerve-cells, and is then said to be insufficient or inoperative; but though our application of the stimulus may not be thus propagated with such intensity as to excite the cell to discharge itself, it may awaken its activity if frequently repeated, and cause it to respond, just as a touch which fails to awaken a sleeper, will do so if repeated. This constitutes the summation of a stimulus. The chemical stimuli are represented by the various mineral and vegetable acids, by alkalis, by ethereal and alcoholic liquids. As a rule, any chemical substance that produces sensation when applied to a sensory nerve, will cause contraction of muscle when applied to a motor nerve, but experiment has shown that the motor nerves are more strongly affected than the sensory by alkaline solutions.

The spinal cord is primarily to be regarded as formed by the union or joining together of many nerve centres, that is to say, of many groups of cells, which commonly act together or in an orderly sequence, producing purposive actions, without any voluntary effort, beyond perhaps supplying the first incentive or stimulus. Even this may be entirely absent, and the animal may have no consciousness of the nerve stimulus or of the muscular actions that follow it. The complete independence of a segment of the spinal cord is well shown in cases where the spinal cord has been crushed in the region of the back by a fall, or a musket-ball, or a sabre-cut. The voluntary movements of the hind limbs are abolished, the animal can neither move them nor feel any injury inflicted upon them. It is said to be paralysed, yet if the skin of the limb be pinched, or touched with a hot body, it will immediately respond by kicking, or by some other spasmodic movement of the paralysed limb. Similarly, by appropriate stimulation the bladder or the rectum may be made to discharge its contents. Such actions or movements are said to be *reflex*. It can be shown that a stimulus applied to the skin excites a wave which travels up the nerve, enters the cord by the superior root of one or more of the spinal nerves, and reaches one of the nerve-cells in the superior cornu. From this it passes into the inferior cornu and reaches

one of the motor cells, and this immediately liberates an impulse, which, emerging by the inferior root, travels down the motor nerve to the muscle. As many sensory nerves are always stimulated, many motor nerves are called into action, and these are so connected and associated together as to produce purposive movements.

In the illustration just given, the reflex movements are said to be *without consciousness*, and they are analogous to those that are constantly taking place in the uninjured animal in the movements of the intestine, of the heart and blood-vessels, of respiration, and of the ducts of glands; but in a large number of cases reflex acts are accompanied by consciousness, as in the case of winking when the eyelashes are touched or the eye is exposed to a bright light, or of coughing or vomiting from tickling the throat with a feather, or of micturition from over-distension of the bladder. When the animal desires to perform one of these purposive and complex movements, it does not transmit a separate impulse to the several muscles implicated in the act, for it knows nothing of them, but by an act of the mind it transmits a mandate to a group of cells which have learned to act together in a definite order and to produce the required effect. Such centres are named co-ordinating centres or nuclei, and of these there are many, as, for example, those governing the movements of the rectum and bladder in the acts of discharging the fæces and urine; those required for parturition, and for the erection of the penis and the ejaculation of semen, which are chiefly situated in the lumbar and sacral regions of the cord; and finally, the contraction of the blood-vessels of the abdomen and lower limbs, which are chiefly situated in the dorsal region.

There appears also to be present in the cord, centres that control the production of animal heat and of the secretion of sweat, these effects being in part due in both instances to changes in the size of the blood-vessels, and in the case of the sweat secretion to direct action of the nerves on the sweat glands.

We must regard the cord as endowed to an eminent degree with impressionability, and the power of inducing reflex acts without consciousness. But the cord is not a receiver of nervous impressions and a generator of nerve impulses only; it is also a conductor transmitting impressions made upon the skin to the medulla oblongata, cerebellum, and cerebrum on the one hand, and impulses originating in these parts to the muscles of the limbs and trunk, and to the other organs of the body.

The medulla oblongata, while it is a prolongation upwards of the spinal cord, and transmits impressions both from the cord to the brain and cerebellum, and downwards from these parts to the cord, is also itself a very important centre, containing many groups of cells which preside over and

govern the complex muscular movements of mastication, insalivation, deglutition, winking, breathing, with its accessory movements of coughing and sneezing.

The *corpora striata* and *optic thalami*, or great ganglia, at the base of the brain, are probably the regions where consciousness first appears, consciousness of the different forms and kinds of nervous stimuli, and the place where conscious efforts or muscular movements are made in response to them. These ganglia are particularly connected with the sense of sight. They are relatively large in the horse, for whilst in man their proportion to the brain may be taken as 5 : 100, in the horse it is 13 : 100.

The outer layer or cortex of the brain is the highest centre of all. It is the seat of the emotions of judgment, memory, reason, and the will. We have seen that it consists of gray substance containing many nerve-cells, which give off fibres that extend to and from the ganglia below and to the periphery of the body. It has often been exposed as the result of accident, and has uniformly been found to be insensitive to direct stimulation, so that large portions have been cut away without pain being experienced even in man. Evidence has accumulated during the past few years, showing that the several convolutions have definite functions, so that one set is concerned with the initiation of movements of the head and neck, another with those of the fore-limbs, and others with those of the trunk and hind-limbs. Special lobes of the brain are also connected with the several senses, the occipital lobes being especially connected with the visual sense, the temporo-sphenoidal lobes with the hearing.

The horse appears to be an animal endowed with a remarkable power of association of definite movements with certain mental stimuli, and with an excellent memory. It will stop before the customers' doors, the sound of the rider's voice will cheer and direct it, and in military evolutions the bugle-calls are quite as well known by the horse as by its rider. It will remember events that are long past. It enters into the spirit of trials of speed and strength, and of games, as those of polo and steeple-chasing, with the utmost zest and enjoyment.

The horse owes his proud position with the dog, as the friend of man, to his docility, his gentleness, his great muscular strength and swiftness.

NERVES, ARTERIES, AND MUSCLES OF THE LIMBS—I

I. Inner Deep Aspect of Thigh

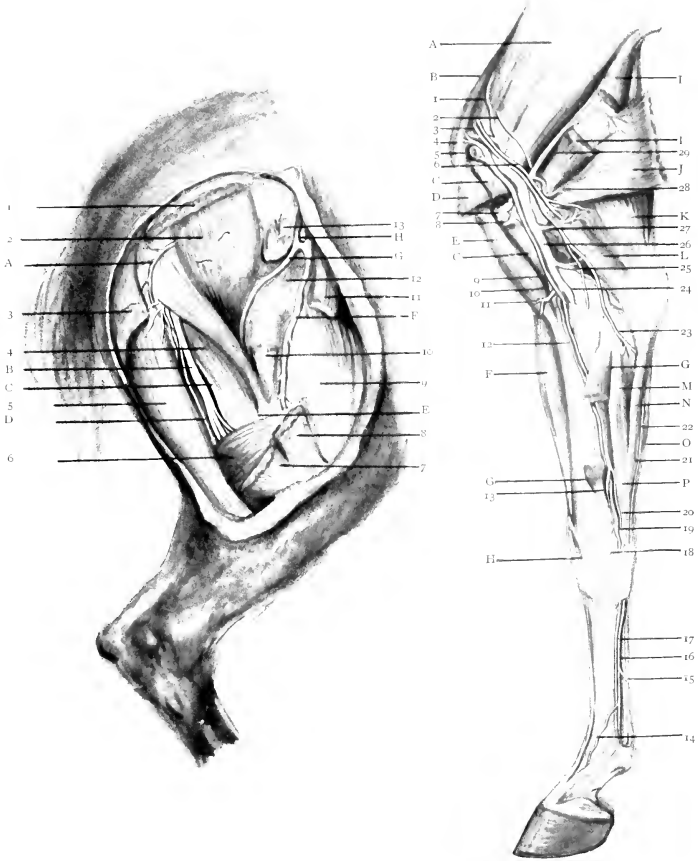
1. Adductors.
2. Obturator externus.
3. Semimembranosus.
4. Biceps femoris.
5. Semitendinosus.
6. Gastrocnemius.
7. Semimembranosus.
8. Adductor magnus.
9. Vastus internus.
10. Pectineus.
11. Sartorius.
12. Tendon common to psoas magnus and iliacus.
13. Pectineus.

A. Obturator artery.
B. Great sciatic nerve.
C. External popliteal nerve.
D. External saphenous nerve.
E. Femoro-popliteal artery.
F. Femoral artery.
G. Deep femoral artery.
H. Prepubic artery.

II. Inner Aspect of Fore-Limb

1. Suprascapular artery.
2. Circumflex nerve.
3. Ulnar nerve.
4. Roots of median nerve.
5. Axillary artery.
6. Musculo-spiral nerve.
7. Nerve to biceps.
8. Prehumeral artery.
9. Median nerve.
10. Musculo-cutaneous nerve.
11. Artery to biceps.
12. Posterior radial artery.
13. Internal plantar nerve.
14. Anterior digital nerve.
15. Oblique branch connecting the internal with external plantar nerve.
16. Internal metacarpal vein.
17. Large metacarpal artery.
18. Small metacarpal artery.
19. Large metacarpal artery.
20. External plantar nerve.
21. Ulnar artery.
22. Ulnar nerve.
23. Ulnar nerve.
24. Anterior radial artery.
25. Ulnar artery.
26. Brachial artery.
27. Deep humeral artery.
28. Artery to latissimus dorsi.
29. Subscapular artery.

A. Subscapularis.
B. Supraspinatus.
C, C. Coraco-humeralis.
D. Posterior deep pectoral.
E. Biceps.
F. Extensor metacarpi magnus.
G, G. Flexor metacarpi internus.
H. Extensor metacarpi obliquus.
I, I. Teres major.
L. Latissimus dorsi.
K. Caput magnum.
L. Caput parvum.
M. Radial head of flexor metacarpi medius.
N. Ulnar head of flexor metacarpi medius.
O. Ulnaris accessorius.
P. Conjoined tendon of flexor metacarpi internus.



NERVES, ARTERIES, AND MUSCLES OF THE LIMBS—I

I. Inner Deep Aspect of Thigh. H. Inner Aspect of Fore Limb.

CEREBRO-SPINAL NERVES

THE CRANIAL OR ENCEPHALIC NERVES

If we examine the base of the brain, a number of nerves are seen to come off from its surface. They vary in size, as they do also in function, and among them are numbered the nerves of the special senses of smell, sight, taste, and hearing. The cranial nerves are arranged symmetrically on either side of the base of the brain, and for the most part distribute their branches to parts on the side from which they arise. There is a want of agreement in this country between human and veterinary anatomists as to the enumeration of the cranial nerves. By the one they are described as nine, by the other as twelve. We need not, however, enter into the pros and cons of this question here, but we give below the numerical designations of each:—

Name.	Veterinary.	Human.
Olfactory Nerves	1	1
Optic Nerves	2	2
Oculo-motor Nerves	3	3
Pathetic Nerves	4	4
Trifacial or Lingual Nerves	5	5
Abducent Nerves	6	6
Facial Nerves (Portio dura)	7	7
Auditory Nerves (Portio mollis)	8	
Glosso-pharyngeal Nerves	9	
Pneumogastric or Vagus Nerves	10	8
Spinal Accessory Nerves	11	
Hypoglossal Nerves	12	9

First Pair, Olfactory.—The first pair of cranial nerves is the olfactory, a number of fine filaments whose superficial origin is the olfactory bulbs. These bulbous bodies are lodged in the ethmoidal fossæ of the ethmoid bone, two depressions in front of the cranium, in which a number of minute openings appear and allow of their passage out of the cranium into the superior parts of the nostrils, where they are distributed over the schneiderian membrane.

The olfactory nerves are the first pair of special nerves, whose function is that of receiving the impressions of odours, which they carry to the brain.

Second Pair, Optic Nerves.—These nerves are derived from two thick bands which wind round the crura cerebri in their course from their deep origin in the corpora quadrigemina.

On reaching the inferior surface of the cranium, the two optic bands

combine to form the commissure or chiasma of the optic nerves, which is lodged in a depression at the base of the cranium—the optic fossa.

It is important to understand the behaviour of these nerves on reaching the commissure. To look at, it would almost seem as if the nerves proceeding from the optic tracts had crossed in their course, and had gone to the eye on the side opposite to that on which they first appear before the chiasma is reached, but this is not exactly the case.

As a matter of fact, the great bulk of the nerves do cross, but a certain number of filaments continue on the original side and pass into the eye on that side. We find, therefore, that fibres from the left side mingle with fibres from the right, and together form the right optic nerve, and *vice versa*. It should also be noticed that some of the fibres are believed to cross from right to left in the optic chiasma, and to pass backward through the opposite optic tract to the brain.

When the nerve leaves the commissure it passes out of the cranium through the optic foramen, and reaches the orbital cavity to pierce the sclerotic coat of the lower part of the globe of the eye, and after passing through the choroid coat, opens out and forms a thin nervous expansion termed the retina.

The function of the optic nerve is to transmit to the brain the impressions made upon it by external objects, or, in other words, it is the nerve of sight.

Third Pair, Motores Oculorum.—These nerves have their superficial origin in the under surface of the cerebral peduncles. From this point they proceed in a forward direction, and enter the orbit through the foramen lacerum orbitale.

This nerve supplies the elevator muscle of the upper eyelid, the internal rectus, the superior and inferior rectus, the retractor oculi, and the small oblique muscle.

It also gives motor branches to the lenticular ganglion, and through it supplies the ciliary muscle and the circular fibres of the iris. It is essentially a motor nerve, and may cause all the parts named to contract.

Fourth Pair, Pathetici.—A very thin, long, and slender nerve originating behind the corpora quadrigemina, from which it descends in a forward and downward direction to the supra-sphenoidal fissure. By this it is conducted to the pathetic foramen, through which it passes into the orbit, and thence to its ultimate destination, the superior oblique muscle of the eye. It is a nerve of motion.

Fifth Pair, Trigeminal.—This is much the largest of the cranial nerves, and the variety and importance of its functions imbue it with more than ordinary interest.

To commence with, it possesses (1) a sensory and (2) a motor root. The sensory root springs from the anterior part of the pons varolii, and has upon it a large elongated body, the *Gasserian* ganglion. From this spring three branches, termed respectively the ophthalmic, superior maxillary, and inferior maxillary nerves.

The motor root is the smaller of the two, and is situated on the inner side of the longer one, with which it takes origin from the pons varolii. From this point it proceeds forward to unite with the inferior maxillary nerve, which is now both sensitive and motor.

The superior maxillary division is the largest of the several branches of this nerve; it leaves the cranium through the foramen rotundum. The ophthalmic, which is the smallest, passes out by the foramen lacerum orbitale, and the inferior maxillary division by the anterior opening in the foramen lacerum basis cranii.

On emerging from these openings the ophthalmic branch gives off—

1. The Frontal or Supra-Orbital after emerging from the supra-orbital foramen is distributed to the skin of the forehead and the upper eyelid.

2. The Lachrymal Nerve to the lachrymal gland and the muscles and skin of the ear.

3. The Palpebro-Nasal Nerve to the inner angle of the eye, the lachrymal apparatus, and the lower eyelid. It also supplies the membrana nictitans, and sends a branch to the sensitive roots of the ophthalmic ganglion.

The **Superior Maxillary Nerve** emerges from the cranium at the foramen rotundum and enters the superior dental canal. It gives off, among others—

1. The Orbital branch to the eyelids and skin.

2. Great Anterior or Palatine Nerve traverses the palatine canal and is distributed to the hard palate and gums.

3. The Staphyline or Posterior Palatine Nerve to the velum palati and soft palate.

4. Nasal or Spheno-Palatine Nerve to the mucous membrane of the nose.

5. The Dental Nerve to the superior molar, incisor, and canine teeth.

6. The Infra-Orbital Nerve to the nostrils and upper lip, after uniting with a branch of the facial nerve.

The **Inferior Maxillary Nerve,** as we have already pointed out, contains both sensory and motor filaments. It gives off—

1. The Masseteric Nerve, to the masseter and temporal muscles.

2. The Buccal Nerve, to the external pterygoid muscle, to the orbital

portion of the temporal muscle, the molar glands, the buccinator muscle, and to the lips.

3. Nerve of Internal Pterygoid Muscle, to the internal pterygoid muscle.

4. Superficial Temporal or Subzygomatic Nerve furnishes small filaments to the guttural pouch and the parotid gland. It sends a branch to join the seventh nerve as it passes on to the face.

5. The Gustatory Nerve, the larger of the branches of the inferior maxillary trunk, is distributed to the mucous membrane of the tongue, and the sublingual and submaxillary glands. This is the nerve of taste. It is joined near its origin by the chorda tympani, a branch of the facial nerve.

6. The Mylo-Hyoidean Nerve to the mylo-hyoideus, and the lower belly of the digastricus.

7. The inferior Dental Nerve enters the dental canal in the inferior maxillary bone, and gives sensory branches to the teeth.

8. The Mental Nerve to the lower lip.

Sixth Pair, Motores Occulorum.—This is a small nerve arising from the anterior part of the medulla oblongata, just behind the pons varolii. It proceeds in a forward direction in company with the superior maxillary nerve in order to reach the foramen lacerum orbitale, by which it enters the orbit with the ophthalmic division of the fifth.

It gives off a small branch to the retractor muscle of the eye, and is then distributed solely to the outer straight muscle of the eye (external rectus).

Seventh Pair, Portio Dura or Facial.—Arising from the medulla oblongata immediately behind the pons varolii in company with the eighth.

From this point it is directed outward, and, with the eighth nerve, enters at once the internal auditory meatus. Then it passes into the aqueduct of Fallopius, and gives off the chorda tympani nerve to join the lingual, and soon emerges from the stylo-mastoid foramen of the petrous temporal bone. Here it gains the under surface of the parotid gland, from which it reaches the face by passing between the gland and the inferior maxilla below its condyle. It blends with the fibres of the sensory subzygomatic branch of the inferior maxillary division of the fifth nerve and forms a plexus (pes anserinus) on the outer side of the masseter muscle.

This nerve supplies the ear and muscles about the poll, the upper belly of the digastricus, the guttural pouch and parotid gland, the stylo-maxillaris, the corrugator supercilii, the orbicularis palpebrarum, the levator labii superioris alaeque nasi, and cervical panniculus, and

gives its ultimate fibres to the cheeks, nostrils, and lips. A branch from this nerve joins the infra-orbital nerve, and is distributed to the upper lip.

Eighth, the Auditory Nerve, arises in company with the seventh nerve from the medulla oblongata, immediately behind the pons varolii. It enters the internal auditory meatus at once, and divides into two branches, one of which is supplied to the cochlea and the other to the vestibule and semicircular canals.

This nerve is for the special sense of hearing.

Ninth, Glosso-pharyngeal.—This nerve arises from the outer edge of the medulla oblongata, and passes from the cranium through the back part of the foramen lacerum basis cranii. At this point it has upon it Andersch's ganglion, from which the nerve of Jacobson is derived.

It now descends behind the great cornu of the hyoid bone to reach the base of the tongue, where it supplies filaments to the mucous membrane and sends others to the muscles of the pharynx.

Branches given off in its course:—A very fine filament (Jacobson's nerve), which enters a small foramen in the petrous portion of the temporal bone to be distributed to the tympanum.

Two or three filaments to the superior cervical ganglion.

A branch which, with some sympathetic filaments, go to the common carotid.

A pharyngeal branch. This passes to the upper wall of the pharynx, and, with the pharyngeal filaments of the pneumogastric and sympathetic nerves, forms a somewhat intricate plexus.

Tenth, Pneumogastric or Vagus.—This is a most important nerve, not only on account of its wide distribution, but equally so in reference to the variety and complexity of its functions.

It is a mixed nerve, and arises from the side of the medulla oblongata immediately behind the ninth nerve. It then passes out of the cranium through the posterior part of the foramen lacerum basis cranii, where it joins the inner division of the eleventh nerve, with which it unites for about an inch of its course.

In the foramen the nerve presents an enlargement—the jugular ganglion. This gives off the auricular branch of the vagus, which enters the aqueduct of Fallopius to join the seventh nerve, and subsequently passes out with it to be distributed to the lining membrane of the external auditory canal. Below the occipital artery it becomes united with the cervical sympathetic cord, and joined in this way it passes down the neck with the carotid artery as far as the entrance to the chest, where it resumes its independence. From this point it passes onwards above the division

of the trachea, and assists in forming the bronchial plexus. It now gives off the œsophageal nerve, which goes to the stomach and the solar plexus.

In its course the pneumogastric nerve gives branches—

(1) To the superior cervical ganglion of the sympathetic.

(2) The pharyngeal branch unites with a branch of the ninth pair given off near the termination of the common carotid, and these, together with a branch of the sympathetic, form the pharyngeal plexus, which distributes fibres to the pharynx and commencement of the œsophagus.

(3) The superior laryngeal nerve enters an opening beneath the appendix of the superior border of the thyroid cartilage, and supplies the mucous membrane of the larynx with sensibility. It also gives branches to the mucous membrane of the root of the tongue, the pharynx, and œsophagus, likewise to the crico-thyroid, and crico-pharyngeus muscles.

The inferior laryngeal differs not only in its point of origin, but likewise in the course it subsequently takes.

The **right inferior laryngeal or recurrent nerve** arises from the parent trunk near to the dorso-cervical artery at the entrance to the chest. It passes round the root of this vessel and escapes from the chest between the carotid artery and the trachea, to which and the œsophagus it gives filaments. It then passes up the neck in company with the former as high as the larynx, and gives its fibres to the posterior crico-arytenoideus, the lateral crico-arytenoideus, the arytenoideus, and the thyro-arytenoideus muscle. Before leaving the chest this nerve gives branches to the cardiac plexus, and communicates with the middle cervical ganglion of the sympathetic.

(4) The **left inferior laryngeal or recurrent nerve** is given off from the pneumogastric opposite the root of the aorta; it then courses its way round that vessel, as did the right round the cervico-dorsal artery. Passing out of the chest between the two first ribs, it follows the carotid artery up the neck to reach the larynx. Here it distributes its branches to the posterior and lateral crico-arytenoideus, the arytenoideus, and the thyro-arytenoideus muscles.

It is longer than the right nerve, having to pass round the aorta, and when paralysed gives rise to the disease known as "roaring and whistling".

A branch of the pneumogastric amalgamates with the middle or inferior cervical ganglion of the sympathetic, and a pulmonary plexus is formed at the bifurcation of the trachea; branches from it follow the divisions of the bronchi along their ramifications, and others enter into the cardiac plexus.

Eleventh, Spinal Accessory.—This nerve arises from the whole cervical spinal cord, and passes up the neck between the superior and the inferior roots of the cervical spinal nerves. In its course along the neck

it gradually becomes thicker by the addition of fresh fibres from the cord, and enters the cranium through the foramen magnum. It receives some fibres from the posterior part of the medulla oblongata, and then, united with the pneumogastric for about an inch of its course, passes out through the foramen lacerum basis cranii. Beyond this point the nerve is directed backward beneath the mastoido-humeralis muscle, giving branches to the superior cervical ganglion, the sterno-maxillaris, the mastoido-humeralis, and finally terminates in the cervical and dorsal trapezius.

It is a nerve of motion.

Twelfth, Hypoglossal.—Originating from the posterior part of the medulla oblongata the hypoglossal nerve leaves the cranium through the anterior condyloid foramen and descends between the pneumogastric and spinal accessory nerves on the exterior face of the guttural pouch. Passing over the side of the pharynx and larynx it is continued onwards beneath the mylo-hyoid and hyo-glossus brevis muscles, and distributed to all the muscles of the tongue.

Soon after leaving the anterior condyloid foramen the hypoglossal nerve receives a considerable twig from the inferior branch of the first cervical pair, and it is further connected with the superior cervical ganglion on the outer part of the guttural pouch.

It is a motor nerve, and excites contraction of the muscles of the tongue during feeding or whenever they are required to move.

SPINAL NERVES

These nerves differ from those last described, in the fact that each of them arises from the side of the spinal cord by two roots—one sensitive, the other motor. The sensitive root is the upper one and has upon it a ganglion. The motor root is the one below. They pass out of the spinal canal together through the intervertebral opening, and then the two roots join their fibres to form a compound nerve, a nerve having motor and sentient properties. Each spinal nerve now divides into a superior and inferior division, and from the latter sends a branch to the sympathetic.

Cervical Nerves.—Of these there are eight pairs. The first cervical nerve leaves the spinal canal through the antero-internal foramen of the atlas. The superior branches accompany the occipital artery and vein to between the rectus capitis posticus and the obliquus capitis superior. At its origin it gives branches to the small muscles about the poll. The inferior branch passes downwards and is distributed to the thyro-hyoid, subscapulo-hyoid, sterno-thyroid, and sterno-hyoid muscles. It sends a small branch to the hypoglossal nerve, and another to the superior cer-

vical ganglion of the sympathetic. It also supplies the skin of the ear on the inner and lower part.

The second cervical nerve leaves the spinal canal through an opening at the anterior part of the dentata, under cover of the obliquus capitis inferior. The inferior branches of this nerve are distributed to the mastoido-humeralis and skin of the ears; the superior branches go to the superior and inferior oblique muscles of the neck. The sixth and seventh, and sometimes the fifth, together with a branch from the brachial plexus, form the diaphragmatic nerve.

From the second to the sixth they communicate with each other, and then divide into three sets of branches; one set joins the vertebral nerve, and goes to the sympathetic or middle cervical ganglion, another is distributed to the mastoido-humeralis, longus colli, rectus capitis anticus major, the scalenus, and to the phrenic nerve, and a third to the skin. The sixth nerve also furnishes branches to the levator anguli scapulæ and rhomboideus muscles, and the brachial plexus receives a twig from its phrenic branch. The superior branches of the last six cervical nerves supply the splenius, trachelo-mastoideus, semi-spinalis colli, and complexus muscles, and the skin in the region of the mane.

The seventh and eighth cervical nerves are expended in the formation of the brachial plexus. Each nerve supplies a branch to the middle cervical ganglion, the former joins the vertebral nerve, the latter passes directly to the ganglion.

BRACHIAL PLEXUS

The mixing or joining together of nerves to form plexuses is one of the methods which nature adopts in order to establish a material relation of distant parts, and to some extent a dependency of one part upon another, so that the whole shall be capable of co-ordinating and acting simultaneously and together. The brachial plexus is a large fasciculus or bundle of nerves resulting from the combination of the inferior divisions of the last three cervical and first two dorsal roots. It is chiefly intended for the supply of the fore-limb with the nerves which animate it.

The branches going to make up the brachial plexus converge together after leaving the spine, the dorsal division winding round the front of the first rib and joining the cervical portion to form a broad flat band which passes between the superior and inferior heads of the scalenus-muscle, and subsequently breaks up into the following branches:—

1. The Diaphragmatic.
2. The Suprascapular Nerve.
3. Nerves to the Pectoral Muscles.

NERVES, ARTERIES, AND MUSCLES OF THE LIMBS II

I. Inner Aspect of Thigh and Leg

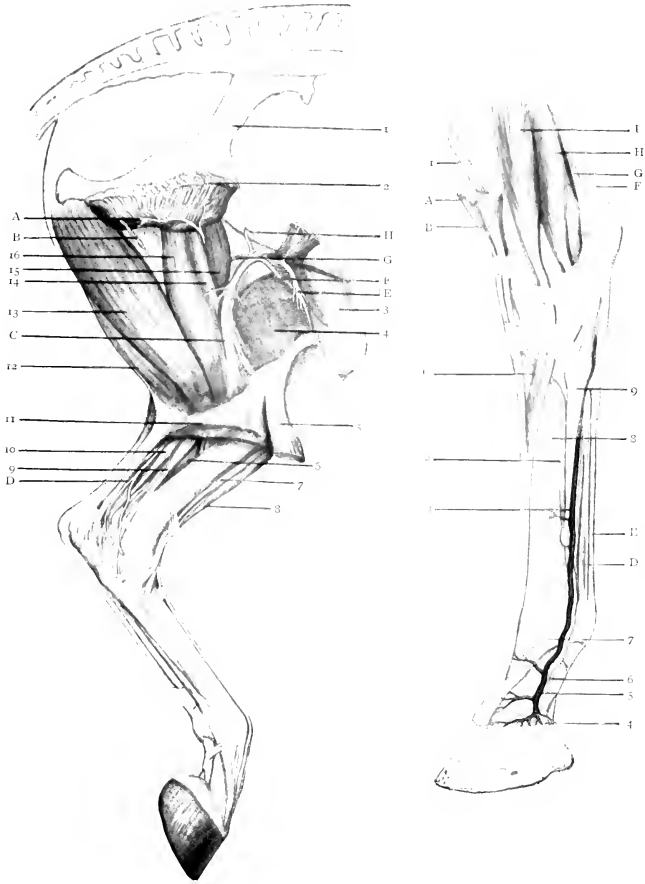
1. Os innominatum.
2. Gracilis.
3. Rectus femoris.
4. Vastus internus.
5. Sartorius.
6. Popliteus.
7. Flexor metatarsi.
8. Extensor pedis.
9. Flexor pedis perforans.
10. Flexor pedis accessorius.
11. Gracilis.
12. Semitendinosus.
13. Semimembranosus.
14. Adductor parvus.
15. Pectineus.
16. Adductor magnus.

A. Branch of obturator nerve.
B. Branch of deep femoral artery.
C. Femoral artery.
D. Bifurcation of posterior tibial nerve into internal and external plantar nerve.
E. Anterior crural nerve.
F. Branch of femoral artery to quadriceps.
G. Deep femoral artery.
H. Prepubic artery.

II. Outer Aspect of Hind-Limb

1. Anterior tibial artery.
2. Large metatarsal artery.
3. Internal metatarsal vein.
4. Coronary plexus.
5. Digital vein.
6. Digital artery.
7. Perpendicular artery.
8. Large metatarsal bone.
9. Small metatarsal bone.

A. Flexor metatarsi.
B. Extensor pedis.
C. Extensor brevis.
D. Lumbricalis.
E. Flexor pedis perforatus.
F. Flexor pedis perforatus.
G. Gastrocnemius.
H. Flexor pedis.
I. Peroneus.



NERVES, ARTERIES, AND MUSCLES OF THE LIMBS—II

I. Inner Aspect of Thigh and Leg. II. Outer Aspect of Hind Limb

4. Nerve to the Subscapularis.
5. Nerves to Serratus Magnus and Levator Scapulæ.
6. The Circumflex Nerve.
7. Nerves to Teres Major and Latissimus Dorsi.
8. The Musculo-spiral Nerve.
9. The Median Nerve (two roots).
10. The Ulnar Nerve.
11. The Subcutaneous Thoracic Nerve.

The Phrenic or Diaphragmatic Nerve is formed mainly by the union of the sixth and seventh cervical nerves, and sometimes also by a small branch of the fifth. It then enters the chest by passing between the two first ribs, and crossing the pericardium reaches the diaphragm, where it terminates. It is a motor nerve to the diaphragm.

The Suprascapular Nerve is short and somewhat thick. It is derived from the sixth, seventh, and eighth cervical roots, and passes between the supraspinatus muscle and the subscapularis. After winding round the anterior border of the scapula it gives branches to the supra-spinatus, and is ultimately expended in the infra-spinatus.

The Anterior Deep Pectoral Muscle receives its nerve supply from the seventh and eight cervical nerves, while the superficial pectoral muscle obtains its fibres from the two roots of the median. A branch also passes to the posterior deep pectoral, and another longer and thicker follows the course of the spur vein.

Nerve to the Subscapularis.—All the cervical roots of the brachial plexus contribute to form the nerve going to the subscapularis. After crossing the supra-spinatus some of the fibres pass between it and the subscapularis, and the rest are distributed to that muscle.

Nerve to Serratus Magnus is derived from the seventh and eighth cervical nerves, which pass through the upper division of the scalenus muscle, and uniting distribute branches to the serratus magnus muscle.

Nerve of the Teres Major is a small nerve situated beneath the shoulder on the inner face of the subscapularis. It springs from the seventh and eighth pairs in common with the circumflex nerve, and gives its fibres to the teres major.

Latissimus Dorsi branch.—A long nerve situated beneath the scapula, and derived mainly from the root of the eighth cervical nerve, and to some extent also from the dorsal roots of the brachial plexus.

It crosses the subscapularis and teres major to gain the latissimus dorsi, where its fibres are expended.

Nerves to the Levator Anguli Scapulæ.—The levator anguli scapulæ, together with the rhomboideus, receive their supply from the

inferior branch of the sixth cervical nerve, and the levator also receives a slight contribution from the seventh.

Radial or Musculo-Spiral Nerve.—This nerve derives its fibres from the seventh and eighth cervical pairs, and also from the first dorsal root. It is the largest of the branches furnished by the brachial plexus. From its point of origin it passes downwards, crossing over the inferior part of the subscapularis and the teres major muscles. It then dips down and takes an outward course under the great head of the triceps, winding round the humerus in the musculo-spiral groove to gain the front of the elbow-joint, where it is found beneath the extensor metacarpi and extensor pedis muscles. In its course it gives branches to the great and small heads of the triceps, and to the scapulo-ulnaris muscles, the caput medium, and anconeus.

Its terminal branches are destined to the extensor metacarpi magnus, flexor metacarpi externus, the flexor pedis, extensor os suffraginis, and skin.

Median Nerve.—The median nerve is formed by the union of two branches: one comes from the sixth, seventh, and eighth cervical, the other from the eighth cervical and the first dorsal. It passes down the limb at first in front of the humeral artery, and continues its downward course in company with the posterior radial artery until a short distance above the knee. Here it divides, the inner branch forming the internal plantar nerve, the outer uniting with the ulnar to form the external plantar nerve. Its branches are distributed to—1, the superficial pectoral; 2, a considerable branch which passes between the coraco-humeralis, to which it gives fibres, and expends itself in the biceps; 3, a branch which leaves the parent trunk at the middle of the humerus, goes to the brachialis anticus, and sends off a branch to the skin of the forearm; 4, to the flexor metacarpi internus and the flexor pedis perforans and perforatus.

The Ulnar Nerve.—This nerve is chiefly derived from the dorsal roots of the brachial plexus. It is less considerable in size than the one just described. Placed behind the humeral artery, it dips down beneath the scapulo-ulnaris, between it and the caput parvum, to reach the posterior part of the inner condyle of the humerus. From this point it proceeds to the back of the forearm, and following the posterior border of the ulnaris accessorius, terminates by joining a branch of the median just above the knee. It assists in forming the external plantar nerve, and gives some twigs to the front of the carpus. The branches given off in its downward course supply the superficial pectoral muscle, the skin of the forearm, and, excepting the external and internal flexors of the metacarpus, all the muscles behind the radius.

Subcutaneous Thoracic Nerve.—A long slender nerve situated

on the side of the chest beneath the panniculus and above the spur vein, whose course it follows, to be lost in the panniculus of the flank. It is formed mainly of the dorsal roots of the thoracic plexus, and to a small extent from the eighth cervical nerve. In its course backwards it gives off branches which anastomose with the second and third perforating intercostal nerves, and forms a net-work over the inner surface of the panniculus. The panniculus extending over the shoulder and arm receives fibres from this nerve.

Circumflex or Axillary Nerve.—This is a nerve of considerable size; it is derived from the seventh and eighth cervical roots, and after crossing the subscapularis soon enters the interspace between that muscle and teres major. It then passes behind the shoulder joint, accompanied by the posterior circumflex artery, and distributes its branches to the teres minor deltoid, mastoido-humeralis, and ultimately reaches the integument in front of the arm.

Behind the shoulder it gives small twigs to the scapulo-humeralis posticus.

Dorsal Nerves, eighteen pairs.—These nerves on issuing from the spinal canal divide into two sets of branches, as we saw occur in the case of the cervical nerves. The upper divisions, which are the smaller, ascend to reach the dorsal muscles and skin of the back, to both of which they are distributed. The inferior divisions descend, and having gained the intercostal spaces, pass downwards along the posterior border of the ribs beneath the pleura as the intercostal nerves.

In their course they give branches to the panniculus and skin, and the first seven or eight terminate in the pectoral muscles and skin covering them, and the last ten are distributed to the rectus abdominis, the transversalis abdominis, and the skin of the belly. The first and second intercostal nerves send branches to the brachial plexus from their inferior divisions.

Lumbar Nerves, six pairs.—The lumbar nerves, like the dorsal, divide, after leaving the spinal cord, into a superior and inferior branch. The former, passing in an upward direction, ramify through to the muscles of the loins, and ultimately reach the skin, where they terminate. The inferior branches are variously distributed. Those of the first two, after supplying the psoas magnus, pass over the edge of that muscle, and are distributed to the muscles of the flank, the skin, and some fine filaments to the muscles of the thigh. The inferior branch of the third nerve supplies the psoas magnus, psoas parvus, and quadratus lumborum, and its ultimate fibres are expended in the skin of the thigh. The fourth, fifth, and sixth lumbar branches contribute to form the lumbo-sacral

plexus. All the inferior branches of these nerves are connected with the great sympathetic.

Sacral Nerves, five pairs.—There are five sacral nerves. The first four pass out of the spinal canal by the sacral foramina, and the fifth by the opening between the last sacral foramen and the first coccygeal bone. After emerging from the spine, they each divide into a superior and an inferior branch. The former of these pass upwards through the supra-sacral openings, and are distributed to the muscles on the side of the sacral spine and to the skin of the croup. The lower branches are much the larger of the two, and pass in a direction downwards and backwards, to be distributed as follows:—The first and second, by joining with the third, fourth and fifth lumbar, form the lumbo-sacral plexus.

The third and fourth pass along the inner side, or even within the texture of the sacro-sciatic ligament, and are joined together by a branch going from one to the other.

The third forms the internal pudic nerve, which winds round the ischial arch, and with its fellow on the opposite side gains the dorsal border of the penis, along which it runs, and ends in the mucous membrane covering the glans penis. In its course from behind forward it gives numerous branches to the corpora cavernosa and the urethral canal, and while in the pelvis, two small ramuscules go to the perineal region, and hæmorrhoidal branches to the anus.

The fourth, together with a branch of the third, innervates the sphincter muscle of the anus and surrounding skin, and the fifth, after giving a branch to the first coccygeal nerve, is expended in the muscles and integument about the base of the tail and the root of the penis.

Coccygeal Nerves.—These number five or six pairs, which decrease in volume from the first to the last. The first coccygeal communicates with the last sacral nerve, and then with others passes backwards, and is expended in the muscles and skin of the tail.

LUMBO-SACRAL PLEXUS

This is a combination of nerves for the supply of the hind-limb. It corresponds with the brachial plexus of the fore-limb in being formed by the inferior branches of the fourth, fifth, and sixth lumbar, and the first and second sacral nerves.

The branches given off from this plexus are as follow:—

1. **Iliaco-Muscular Branches.** Small branches given to the psoas magnus, psoas parvus, and iliacus muscles.

2. **Anterior or Great Crural Nerve.**—This is a nerve of considerable

ANATOMY OF HORSE'S HEAD

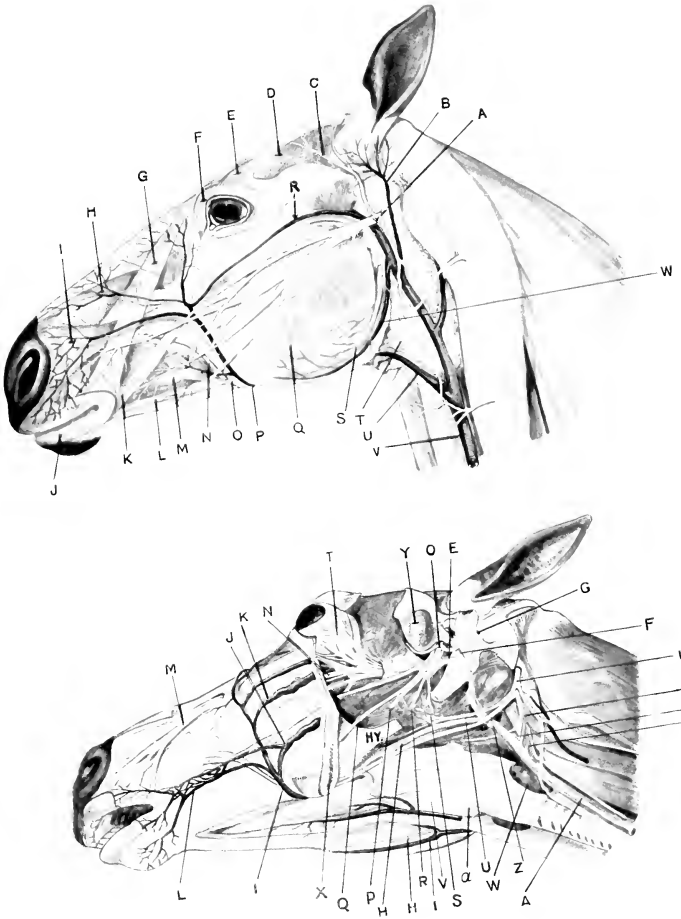
FIG. I

A. Seventh nerve.
B. Posterior auricular vein.
C. Anterior auricular vein.
D. Temporalis muscle.
E. Corrugator supercilii.
F. Orbicularis palpebrarum.
G. Levator labii superioris alæque nasi
H. Levator labii superioris proprius.
I. Dilatator naris lateralis.
J. Orbicularis oris.
K. Zygomaticus.
L. Depressor labii inferioris.
M. Buccinator.
N. Stenson's duct.
O. Submaxillary artery.
P. Submaxillary vein.
Q. Masseter muscle.
R. Temporal vein
S. Maxillo-muscular artery.
T. Parotid gland.
U. Submaxillary vein.
V. Jugular vein.
W. Maxillo-muscular vein.

FIG. II

A. Common carotid artery.
B. External carotid artery.
C. Internal carotid artery.
D. Occipital artery.
E. Internal maxillary artery.
F. Superficial temporal artery.
G. Posterior auricular artery.
H, H. Right and left submaxillary artery
HY. Hyoid bones (divided).
I, I. Right and left submaxillary veins.
J. Buccal vein.
K. Alveolar vein.
L. Buccal plexus.
M. Infra-orbital nerve.
N. Superior maxillary nerve.
O. Inferior maxillary nerve.
P. Inferior dental nerve.
Q. Lingual or gustatory nerve.
R. Mylo-hyoid nerve.
S. Masseter nerve.
T. Ophthalmic nerves and vessels.
U, U. Glosso-pharyngeal nerve.
V. Submaxillary gland.
W. Thyroid gland.
X. Section of lower jaw.
Y. Tempero-maxillary articulation.
Z. Hypoglossal or twelfth nerve
a. Larynx.

B



ANATOMY OF THE HORSE'S HEAD

size formed by fibres from the fourth and fifth lumbar roots, and in part also from the loop between the third and fourth. Descending between the psoas magnus and parvus, it passes downwards at the outer side of the external iliac artery under cover of the sartorius, and after crossing the conjoined tendon of the psoas and iliacus muscles, ends in a number of branches, which pass between the vastus internus and rectus femoris to be distributed to the extensors of the legs.

It gives off the internal saphenous nerve, and sends branches to the rectus femoris.

3. The **Obturator Nerve** is situated beneath the peritoneum on the inner side of the pelvis, and follows the course of the artery of the same name through the obturator foramen to the internal aspect of the thigh. It is derived from the fourth and fifth lumbar roots, and gives branches to the obturator externus, adductors of the thigh, the pectineus and gracilis muscles.

4. The **Anterior and Posterior Gluteal Nerves,** also called the small sciatic nerves. These nerves leave the pelvis by the great sciatic notch. The anterior gluteal consists of four or five branches, which are distributed to the gluteus medius, the tensor vagina femoris, vastus externus and internus, and the gluteus externus. The posterior gluteal nerve is represented by two branches—a superior and inferior. The superior supplies the superficial gluteus, the middle gluteus, and the biceps femoris. The inferior branch, after passing over the outer side of the tuber ischii, is destined to the skin of the thigh, the semitendinosus, and with a branch of the internal pudic nerve to the structures of the perineum.

The **Great Sciatic Nerve** is the largest in the body. It is derived from the lumbo-sacral plexus, and issues from the great sciatic opening as a broad white band; thence it takes a downward course between the sacro-sciatic ligament and the gluteus maximus. On reaching the thigh it is lodged between the biceps femoris and semitendinosus, having the semimembranosus and great adductor of the thigh supporting it within.

On nearing the leg it passes between the two heads of the gastrocnemius muscle, when it takes the name of the internal popliteal nerve. This is continued on as the posterior tibial, which dividing, forms the internal and external plantar nerves. In its course down the limb it supplies a slender branch to the obturator internus, pyriformis, gemelli, and quadratus femoris.

The **External Popliteal Nerve** is a branch of considerable size given off from the great sciatic near to the gemini muscles. It then passes downward and forward between the biceps femoris and the outer head of the gastrocnemius. On reaching the outer lateral ligament of the stifle it divides into the musculo-cutaneous nerve and the anterior tibial.

The **Musculo-Cutaneous branch** is situated beneath the tibial aponeurosis. It passes down the leg along the union of the peroneus and extensor pedis, and ultimately is distributed to the skin on the outer side of the metatarsus. In its course it gives branches to the peroneus.

The **Anterior Tibial Nerve,** after leaving the one last described, passes underneath the extensor pedis muscle, and having supplied branches to it, the flexor metatarsi, and short extensor of the foot, continues its course downwards in front of the leg as far as the hock joint; it then accompanies the large metatarsal artery, and finally ends in the skin on the outer side of the canon.

The **Internal Saphenous Nerve.**—This is a branch of the anterior crural nerve, from which it is given off at the brim of the pelvis. From this point it passes downwards in company with the femoral artery, and gives branches to the sartorius muscle.

About the middle of the thigh it reaches the surface by passing between the last-named muscle and the gracilis, accompanied by the saphenous vein and artery. It divides into an anterior small and a posterior larger branch, which supply the inner and front and the posterior and back parts of the thigh respectively.

Its ultimate fibres are distributed to the skin on the inner and back part of the leg as low as the hock.

The **External Saphenous Nerve** leaves the great sciatic, and passes over the outer head of the gastrocnemius under cover of the biceps femoris, where it receives a branch of the external popliteal nerve. It then passes down the leg in company with the saphenous vein on the outer and front part of the gastrocnemius tendon, and continuing its course over the hock joint, is ultimately expended in the skin of the outer part of the metatarsus.

The Internal Popliteal Nerve.—This nerve consists of a bundle of nerve branches proceeding from the great sciatic. Passing downwards and forwards between the two heads of the gastrocnemius muscle, it gives branches to it, to the flexor perforatus, the soleus, the perforans, and flexor pedis accessories. Finally it gives off a long branch, which passes between the perforatus and the inner head of the gastrocnemius as the posterior tibial nerve.

The Posterior Tibial Nerve.—The posterior tibial is a branch of the internal popliteal. In passing down the leg it is situated beneath the inner head of the gastrocnemius. It then becomes enclosed in the deep fascia of the leg, on the inner side of which it descends, and at the hock divides into two parts to become the internal and external plantar nerves. These enter the tarsal sheath in company with the plantar arteries, and separate from each other behind the hock.

From this point they proceed down the leg along with the perforans tendon, and divide as in the fore-limb to supply the foot.

The **Anterior Tibial Nerve** commences on the outer side of the stifle joint, and dips down between the peroneus and extensor pedis muscle, under cover of which it passes down the leg. On reaching the hock it bears outwards, and, together with the large metatarsal artery, passes down the limb to the fetlock joint, and expends itself in the skin on the outer side of the os suffraginis. It gives branches to the extensor pedis and flexor metatarsi, and on reaching the front of the hock some twigs to the extensor brevis.

DISEASES OF THE NERVOUS SYSTEM

Affections of the central nervous system, including the brain and spinal cord, must necessarily be of a very grave character. Physiologists allow that the brain is chiefly concerned with the mental functions, but, in addition, it also presides over special movements, some of which are voluntary while others are of the excito-motor character. Derangement affecting any important part or nerve centre, either in the form of excess or deficiency of blood, undue pressure, or structural changes, produces either exalted function, or drowsiness going on to stupor, or paralysis.

Disease of the cerebellum or smaller brain causes giddiness and failure of the normal power to regulate the functions of locomotion.

The causes of cerebral derangement are numerous. As the brain presides over many important functions of the body, it is also sympathetically affected when the organs which perform those functions become the seat of structural or functional changes due to accident or disease.

The brain is invested by certain membranes which afford protection on the one hand, and on the other act as a medium through which pass the vessels carrying the necessary supply of blood for the nourishment of its tissues and the exercise of its function.

CEREBRITIS AND MENINGITIS

Very early in the history of veterinary science the French writers separated diseases of the brain into two distinct forms, which were designated by different terms—cerebritis when the substance of the brain was affected, and meningitis when the inflammation attacked the membranes (meninges) which cover the brain.

The necessity for the distinction was at one time disputed, but it is now quite clearly recognized; in fact, the two conditions of disease are

indicated by totally different symptoms. When inflammation affects the intimate structure of the brain the prominent signs are loss of sensibility and consciousness more or less complete, and various degrees of paralysis. None of these symptoms are present in inflammation of the meninges, of which violent excitement, pain, tenderness, delirium, and convulsions are the chief manifestations. In the case of disease being confined to the brain there is seldom any marked disturbance in the circulatory system, but in meningitis both the pulse and respiration are excited in a high degree. To put the differences concisely, it may be said that in disease of

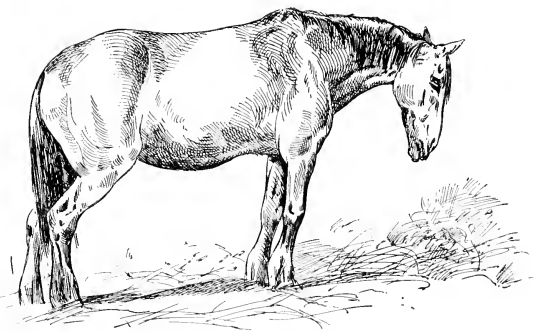


Fig. 177.—Sleepy Staggers

the brain substance, diminished sensibility, loss of power of motion, and deranged volition are the characteristic features, while inflammation of the investing membranes of the organ is indicated by spasms, convulsions, violent pain, delirium, and frenzy. Impaired consciousness may arise from disease of the stomach. The affection which is described as "stomach staggers" might probably be, in popular phrase, referred to as a sick headache due to an attack of indigestion, the brain being sympathetically affected. The symptoms of the disorder are generally observed after a full meal, which the horse probably swallows rapidly owing to a previous long fast. The first indication is a slight dulness, the eyelids being drooped, and the nose rested against the manger. If compelled to move, the animal staggers; hence the name given to the disease.

In very pronounced cases the drowsiness may be followed by delirium, or sometimes severe convulsive twitchings of the muscles. Now and then a violent excitement supervenes, and the animal throws himself about

in various directions in a condition of actual frenzy. In some of these erratic movements the horse may injure himself, or the attendant if he happens to come in his way, but it is evident that there is no intention to do mischief.

The treatment of the disease, to be successful, must be adopted as soon as the first indications are apparent. The animal should be removed to a loose-box and freed from all restraint; food should be kept out of his reach, but he may be allowed to drink any quantity of water. In former times the treatment on which the greatest reliance was placed was the immediate employment of the lancet and the withdrawal of a large quantity of blood. This system, however, has been discontinued for many years past, and instead it is usual to rely on the administration of a strong aperient, together with antiseptic agents, as hyposulphite of soda. Four to six ounces of solution of aloes, or more, according to the size of the horse, forms a useful purgative; and if the drowsy condition is extremely marked, aromatic spirit of ammonia in doses of from one to two ounces every two or three hours, while the condition remains, is likely to be effective. Benefit will also be derived from sponging or douching the head with cold water at short intervals, or by the application of ice-bags to the poll.

VERTIGO

Vertigo, megrims, or giddiness may be associated with organic disease of the brain, or be occasioned by derangement of the liver or other organs of the digestive system. A fit of vertigo may also arise from the action of the sun's rays upon the unprotected head, or it may be due to the retention of blood in the vessels of the brain consequent upon pressure of a tight collar. A single attack, which may occur at any time during a journey, is sometimes difficult of explanation; when a hot sun and a tight collar are both present they will naturally be looked upon as the cause of the fit, but in the absence of either it will be impossible for anyone to decide whether it was due to some chronic disorder in the brain or to derangement of the digestive organs. In these cases a direct diagnosis is only possible when the history of the animal is known. It may, however, be suggested that a sudden and violent attack, under the influence of which the horse suddenly stops, raises and shakes his head, and then drops down in a state of partial unconsciousness, is most likely to be consequent on some cause which is acting at the moment, such as heat, pressure on the vessels of the neck, or some acute disturbance of the liver.

Vertigo which arises from organic disease of the nervous centres, is in most cases a disorder of gradual development. The first attack is extremely

slight, and probably attracts very little attention; the driver may notice that the horse occasionally shakes his head, or turns it to one side as though he were annoyed by something which had entered the ear; after a short time the animal ceases to behave strangely, and finishes the journey without any further indication of disturbance. Nothing more may be thought of the matter until the recurrence of the attack after the lapse of a week or

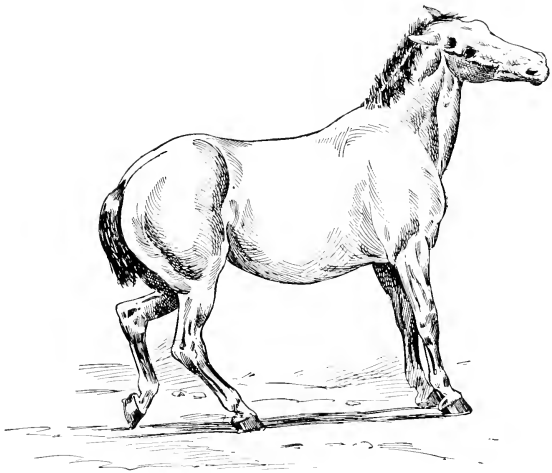


Fig. 178.—Vertigo or Megrims

more, and even then no suspicion of megrims is probably excited until a more severe attack occurs.

Post-mortem examinations have been made of horses which have suffered from chronic vertigo, the fits occurring at intervals of a few weeks or months during several years of the animals' lives. The results of such examinations were in some cases unsatisfactory; in others calcareous nodules and tumours, varying in size from a pin's head to a pigeon's egg or larger, have been found in the plexus of vessels in the lateral ventricles of the brain. Frequently, however, the search for morbid appearances in the brain and spinal cord has been attended with disappointment.

Attacks of vertigo may sometimes happen in consequence of injury to the head; a blow accidentally or intentionally inflicted may produce

slight concussion, or may even result in the depression of some of the bones forming the cranial cavity, in which case stupor will result, and will continue until the depressed portions of bone are elevated by means of a surgical instrument.

When the injury is slight, the fit of giddiness which follows generally passes off in a short time and leaves no trace behind; but the rider or driver, being probably unaware that the animal has been struck on the head, is disposed to look upon the attack as a case of megrims of the ordinary kind. The fact, however, of the attack not recurring would be a sufficient evidence that the injury is not permanent.

Treatment.—As the occurrence at irregular intervals of fits of vertigo is at the least annoying, and cannot be said to be unattended with danger to the rider or driver, it is naturally a subject of enquiry as to what can be done in the way of prevention. If any positive cause, such as a tight collar, is detected, the remedy is of course perfectly obvious. Should symptoms of disease of the liver be present, a dose or two of aloes with calomel may be given with benefit; but if there is no obvious cause, the conclusion will necessarily be that there is some morbid condition of the central nervous system, and beyond attending to the animal's general health by judicious feeding and properly regulated work or exercise, nothing can be done. Horses suffering from chronic brain disease should never be hurried or called upon to undergo severe exertion. Moreover, they should be fed two or three hours before being employed in any kind of work, and food should be given in small quantities and often.

ABSCESS IN THE BRAIN

A more serious result of a blow on the head is the formation of abscess in one of the hemispheres of the brain, or inflammation of the membranes, which is usually indicated by violent excitement. Abscess in the brain also occurs not uncommonly when, in consequeuce of a vessel being punctured in the act of opening an abscess, a quantity of pus may get into the blood-stream, causing the condition which is known as *pyæmia*. Abscesses in various parts of the body are the result of this contamination of the blood, and the brain is a very favourite situation for the deposit of pus. The first indication of the occurrence is the appearance of drowsiness, gradually increasing to unconsciousness, in which condition the animal dies. No treatment is likely to be of any avail.

EPILEPSY

Epilepsy, eclampsia, catalepsy, and chorea (St. Vitus' dance) are all disorders of the nerve centres, and are associated with eccentric muscular action, and often with derangement of consciousness, but horses are very rarely attacked by any of them.

Epilepsy is a peculiar affection almost unknown in the horse, but not uncommon in the dog. The exact pathological conditions of the brain or spinal cord on which the intermittent attacks or epileptic fits depend are not known. It is even uncertain whether the origin of the malady is centred in the brain or spinal cord, although recent experiments lend considerable force to the view of the brain rather than the spinal cord being the seat of the derangement. Characteristic epileptic fits may be produced in dogs while under chloroform after complete disconnection of the brain from the spinal cord. Injection of a minute dose of absinthe into the circulation in an animal thus prepared is quickly followed by all the signs of epilepsy, and dogs utter maniacal cries, which, of course, are purely the result of reflex action, the dog being at the time unconscious.

The **Symptoms** of an epileptic fit are well known. Usually there is no marked premonitory sign of an approaching attack. An animal in a state of health, apparently, may suddenly reel and fall over on its side, in the case of a dog uttering cries which soon cease, while the whole muscular system is in a state of convulsive action. Urine and fæces are involuntarily discharged; a quantity of foam collects about the mouth. In a short time the convulsions cease and the animal regains consciousness, and is soon restored to its ordinary condition, showing no further symptoms of illness until the sudden occurrence of another fit.

Considering the great difficulty of disconnecting severe forms of megrims in the horse from epilepsy, it is not remarkable that some writers record cases of equine epilepsy. It is, however, rarely if ever the case that the horse suffers from this disease, and certainly not in that typical form in which it is seen in the dog.

Several forms of epilepsy are described by writers, for example, spontaneous, symptomatic, traumatic, and reflex epilepsy, and in all these the attack may be serious or benign. Spontaneous epilepsy is the result of functional disturbance of the brain, amounting to general irritability, which disposes the subject to an attack under trifling influences, such as fear or any kind of mental excitement. Horses are said to have suffered when alarmed by a display of fireworks, or the passing of a train, or from suddenly passing from a subdued to an intense light. Symptomatic epilepsy is the form of the disease which is associated with structural changes

in the central nervous system, as thickening of the membranes of the brain, deposits of pus, or the presence of parasites. Traumatic epilepsy is due to injury, as, for example, blows upon the cranium causing compression of the nerve structures from effusion of blood or the depression of the bony boundaries of the cavities in which the brain and spinal cord are contained. Reflex epilepsy may occur in consequence of irritation affecting the terminal branches of nerves in remote parts. Such irritation depending upon pressure exercised by foreign bodies, irritation caused by parasites in the digestive organs, affections of the mouth due to the changes which occur in course of dentition. All the above forms of epilepsy, when connected with special liability to nervous excitement, may be considered as hereditary.

ECLAMPSIA

This disease borders so closely upon the one previously considered, epilepsy, that its manifestations are allowed to be identical with those of reflex epilepsy. It is also stated that eclampsia may be transferred into true epilepsy; the main distinction appears to be that the convulsive spasms affect chiefly the extensor muscles, and appear without any disturbance of the mental conditions and independent of any structural alterations. In fact, the disease is really one of pure motor-nervous excitability.

CHOREA (ST. VITUS' DANCE)

This disease is perfectly well known as it affects the dog. It is frequently one of the results of distemper; its chief manifestation is constant rhythmical contraction and spasm of some of the muscles of the neck or extremities, usually the fore extremities. Animals which suffer from this disease frequently retain their health for a considerable time, but when chorea affects dogs which have recently recovered from distemper, the constant excitement arising from the incessant muscular spasms interferes with the complete restoration of the animal, and occasionally ends in fatal paralysis. Cases of localized muscular spasm have been described in the horse under the name of chorea, but it must be allowed that the disease in that animal, if it occurs at all, is extremely rare.

STRINGHALT

This condition, which is very well known to horsemen, is another of the ill-defined affections of the nervous system. The condition is indicated by spasmodic movement of the muscles of one, sometimes of both hind-legs, and occasionally one or both of the fore-legs. The effect of the spasm is to

cause an extraordinary jerking upwards of the affected extremities, after which the foot is brought forcibly to the ground. The disease differs from chorea, as the symptoms are only developed during progression, whereas in chorea the muscular spasms are constant even during sleep.

In some cases stringhalt is only exhibited occasionally and under special conditions, as when the horse is made to turn sharply round, or when observed while quietly moving in his box, but it generally becomes more pronounced as the animal advances in age or when he is excited. No treatment has been found to be effective in controlling the muscular movements.

APOPLEXY

In very hot seasons horses which are called upon to undergo violent exertion are likely to suffer from cerebral derangement due to determination of blood to the vessels of the brain. This condition is correctly described as sunstroke.

According to the duration of the active causes the final consequences will vary. In the first instance, symptoms will consist of dulness, general depression varied by periods of excitement. If the causes continue, the voluntary movements of the animal may be interfered with, and finally it may fall in a state of unconsciousness. The worst consequence which is to be apprehended is the rupture of some of the overcharged vessels of the brain and escape of blood into the tissue of the organ. If the hemorrhage is sudden and considerable the result will be an apoplectic fit, which may be immediately fatal. The fit will probably be preceded by an irregularity in the animal's movements, trembling, turning round or backing, ending in a sudden fall, loss of consciousness, and possibly death in a few minutes. A partial recovery may, however, take place, and the animal may live for some days or weeks, but a fatal result is almost certain to follow.

When the hemorrhage is slight the symptoms will be those which have previously been described, *i.e.* irregular movements followed by drowsiness, from which the animal will gradually recover, but in such instances a small clot of blood may be left in the substance of the brain and lay the foundation for future mischief.

Treatment.—On this subject a great difference of opinion exists; bleeding and cold applications are advocated, or, on the other hand, stimulants are suggested in order to overcome the drowsy and depressed state into which the animal has fallen. It is probably the case that ice-bags to the head and bleeding would be beneficial when the animal is

suffering from an apoplectic fit, while the use of stimulants might be resorted to when the more urgent symptoms have ceased.

In all cases where the power to swallow exists, a strong dose of physic should be promptly administered.

CRIB-BITING

In connection with diseases of the nervous system it is necessary to refer to certain abnormal actions commonly described as nervous habits, which are not usually recognized as diseases, but which, as they are not normal, *i.e.* are not in accordance with the rule as applied to the actions of healthy animals, must be classified as abnormal.

"Cribbing" or "tic", "wind-sucking", and "weaving" may be taken as examples of diseases which are more or less connected with some ill-defined derangement of the nervous system. Tic or cribbing has been carefully studied in its various forms by Continental veterinarians. Friedrich Berger and Fröhne, in their work on the pathology of the domestic animals, allude to the causes of cribbing as being complex and variable in their nature. Idleness is said to be one cause of the acquirement of the habit. Horses, like other creatures, are supposed to invent some kind of pastime when left alone in a stall or box, and the manger, drinking-trough, or piece of chain or rope lends itself to this kind of indulgence. In the case of some animals it seems that no assistance from external objects is necessary, as they succeed in performing the actions of a crib-biter without seizing the manger with their teeth or obtaining any other support. By contracting the muscles of the neck they contrive to keep the head in a fixed position, and can make the peculiar noise which is common to crib-biters.

Fig. 179.—Throat-strap for Crib-biting

Among the causes of cribbing heredity is referred to as having considerable influence. Horses it is said become crib-biters and wind-suckers apparently from imitation, although it would seem that a certain amount of nervous excitability is necessary as a predisposing cause, as it may be that only one animal out of a very large number which are exposed to the same temptation acquires the habit.

The habit of cribbing or wind-sucking has somewhat fancifully been

attributed to the use of a curry-comb in the act of cleaning, as when the instrument is used with much force it causes a good deal of irritation, which the animal indicates by biting at anything within its reach; and it is supposed that the habit of biting and making spasmodic movements of the lips and other parts at the same time might finally lead to cribbing.

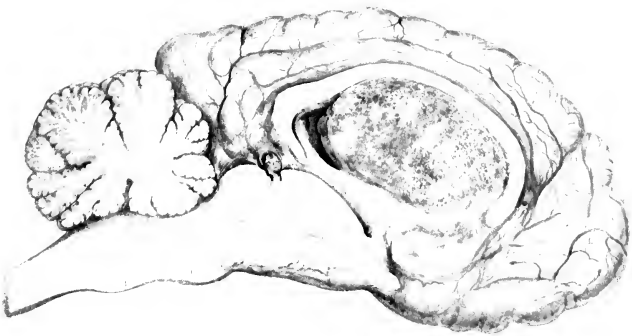
Cribbing and so-called wind-sucking induce occasional attacks of colic from the quantity of air which is developed in the stomach, and both are associated with an irritable condition of the mucous membrane of the digestive organs, which we believe to be a cause of these remarkable acts. In a legal point of view cribbing and wind-sucking would amount to unsoundness if that term is construed strictly, and in some parts of the Continent the habit is recognized as sufficient to constitute a breach of warranty. In any case, a horse addicted to crib-biting or wind-sucking, or both, can hardly be said to be as useful for its intended purpose as an animal which is free from such defects. If there were no other objection to be urged, it would be sufficient to point to the well-known fact that the animal loses flesh and becomes thin.

Treatment.—The owner of a crib-biter or wind-sucker is very anxious to find out some means of cure, and various mechanical appliances have been suggested for the purpose. The plan of using movable mangers and troughs, and avoiding all projecting posts on which the animal may place his teeth and get a point of support, has been said to be successful in cases of crib-biting, but it is obviously of no use in the case of a wind-sucker, which does not require such assistance. In most instances of crib-biting and wind-sucking the ordinary throat-strap (fig. 179), which is arranged to be buckled round the throat, acts as a preventive, but to be effectual it must be constantly employed while the animal is in the stable.

The other habit which has been referred to under the term *weaving*, consists in swaying the head and fore part of the body from side to side like a bear. Although perhaps less objectionable than wind-sucking, it is, nevertheless, a serious fault, since the animal which is addicted to it is constantly using his legs when he should be resting them. Weaving is most commonly seen in horses which are tied to the manger by means of two side-ropes fixed to the head-collar and carried through rings on each end of the manger. At the end of each rope a perforated wooden block is fixed on purpose to prevent the removal of the halter-ropes from the rings.

The habit of weaving may sometimes be corrected by keeping the animal in a loose-box without any head-collar or halter-ropes. This, how-

ŒDEMA OF CHOROID PLEXUS



BRAIN TUMOUR

ever, is not always successful, as in some cases the animal continues the lateral movements of the head even when it is left altogether without any means of restraint.

TUMOURS IN THE BRAIN AND CRANIUM

Tumours in the brain are not of rare occurrence in the horse, although they are very limited in variety. Moreover, they are seldom found to exist save in the lateral ventricles or cavities within the hemispheres. They are almost invariably of that variety termed "psammoma", a structure comprising a quantity of fibrous tissue, in the mesh-work of which are found granules of earthy matter, fatty particles, and thin glistening plates of cholesterine.

These tumours are developed in the fringe of vascular membrane, termed the "choroid plexus", which is situated on the floor of the lateral ventricles.

They vary in size from a pin's head to a hen's egg, and frequently occur in both ventricular cavities. Being slow in their growth they seldom produce any obvious disturbance in the conduct of the animal until they have reached considerable dimensions, although in the course of their development the ventricles become much dilated, and a considerable amount of brain matter is caused to be absorbed by the pressure which they make upon it. They are usually ovoid in form, of a bluey-gray appearance, smooth on the surface, and firm to the touch.

Brain tumours in the horse are mostly found in the adult and later periods of life, although the writer has removed them from the ventricles of so young a horse as a four-year-old.

Cause.—As to the origin of these formations, nothing definite can be said; inasmuch, however, as they are more prevalent in harness horses than others of the riding class, it has been suggested that the pressure of tight, ill-fitting collars on the jugular veins may, by interrupting the circulation from the brain, be the means of causing their development, and it is very likely this may be a predisposing or even an exciting cause.

Symptoms.—The symptoms developed as the result of the continued growth of these formations may be of a chronic or an acute and fatal character.

In the former the animal suffers periodic attacks of loss of power and unconsciousness for some time, the intervals between each attack becoming shorter as time goes on, and the attacks more and more severe. They are specially excited when the horse is worked on a full stomach, or urged

too freely uphill when the pressure of the collar is increased, or driven in face of a hot sun. The frequent occurrence of these symptoms in the early spring and during the summer is mainly on account of exposure to the last-named cause.

The attack comes on without warning. The animal stops and suddenly falls to the ground, the muscles quiver or are rigidly set, the eyes roll, there is loss of consciousness, and for a time also of feeling and muscular power. After a brief period the stricken beast regains his lost powers and is able to rise, but for several days he remains dull, feeble, and stupid, and altogether unfitted for work. In other cases the animal hangs his head, and presents an expression of drowsiness and an indisposition to move. In less severe attacks he will suddenly stop while being driven, lay back his ears, shake his head violently, or throw it up and down without any obvious reason, and in a few minutes resume his journey as if nothing had happened.

In the more severe attacks the patient is stricken down paralysed and unconscious and quickly succumbs.

Treatment in these cases is of no avail, and although something may be done to ward off the attacks by a judicious system of general management and feeding, horses affected with brain tumours are dangerous beasts to possess, and should be destroyed.

ŒDEMA OF THE CHOROID PLEXUS

This is a condition in which the choroid plexuses of the ventricles are infiltrated with fluid which has escaped from the fine net-work of veins of which they are mainly composed. So far as is known it is of somewhat rare occurrence. It may, however, be more common than is generally supposed, were post-mortem examinations more frequently made of the brain in those cases where death follows upon sudden and complete coma.

The causes of œdema of the choroid plexuses is not well established, but in the case of which an illustration is here given (see Coloured Plate) the horse had been the subject of influenza, and appeared to be making a good recovery. He was, however, suddenly seized with dulness, followed by deep coma, and death occurred twenty-four hours later.

Post-mortem examination showed clots of coagulated blood obstructing the veins leading from the plexuses into the veins of Galen.

There was nothing either in the history of the case, or in the post-mortem inspection, to show why the blood should have clotted and obstructed the circulation in these veins. A blow on the head in such

circumstances might have caused it, or it may have resulted from some change in the blood consequent on the disease.

Where, as in this instance, the choroid plexuses were torn up, treatment could be of little avail.

EXOSTOSES OR BONE TUMOURS

Hard ivory-like growths from the petrous temporal bone sometimes extend into the cavity of the cranium and occasion pressure upon and absorption of the brain substance. These tumours, developing very slowly, afford the neighbouring parts an opportunity to accommodate themselves for a time to the altered state, but sooner or later the pressure they impart to nerves and vessels produces various forms of structural and functional derangement, among which may be mentioned deafness, paralysis of the muscles of the face, loss of motor power, unsteady movements, convulsive fits, followed by apoplexy and death.

Exostoses or bone tumours sometimes occur on the floor of the cranium as the result of a blow on the poll or back of the head, such as would be inflicted by a horse falling backward or striking the head violently against some fixed object. In these cases blindness may follow as a consequence, from pressure on the optic nerves at their bifurcation; or the muscles of the eye may suffer paralysis, and disorders of some of the other nerves issuing from the base of the brain may result.

THICKENING OF THE MEMBRANES

Professor Williams, in his *Principles and Practice of Veterinary Medicine*, refers to a case in which the dura mater or outermost covering of the brain attained a thickness varying from one inch at the base to several inches at the anterior part of the cranium, causing absorption of the frontal and ethmoid bones, and closing the frontal sinuses. The horse in which this was discovered had presented signs of brain disease, sleepiness, partial paralysis, blindness, and paralysis of the muscles of mastication for a considerable period before its death.

"It is very probable", Professor Williams remarks, "that this condition was the result of an injury, such as a blow upon the head, causing chronic inflammation."

DISEASES OF THE SPINAL CORD AND ITS MEMBRANES

ACUTE SPINAL MENINGITIS—INFLAMMATION OF THE MEMBRANES OF THE SPINAL CORD

Acute inflammation of the coverings of the spinal cord is of seldom occurrence, and mostly involves the two innermost membranes—the pia mater and arachnoid.

The **causes** which give rise to this disease are for the most part the result of injury, but it may also follow upon exposure to cold easterly winds and wet, especially in the case of a horse that is heated after a fast run with hounds and much jumping, or after a period of heavy draught. Tumours in the spinal canal, and the bursting of abscesses into it from disease of the vertebræ, may also occasion it.

Symptoms.—These will vary in severity, according to the intensity of the cause. They may either be sudden and severe in their onset or slowly progressive. In the former case the disease is ushered in by rigors or shivering, followed by paroxysms of pain in the course of the spine, exhibited more especially when the animal is made to move. Later, sudden and repeated fits of spasmodic contraction of the muscles of the limbs appear, causing them to be suddenly jerked upward and forcibly brought to the ground. The movements become unsteady and the fetlocks knuckle over, the patient loses the power to stand, and sooner or later becomes completely paralysed. When on the ground he makes repeated attempts to rise, during which there are violent fits of struggling and painful spasms of the muscles of the limbs and back.

During these paroxysms the face wears a drawn and anxious expression, deep groans are emitted, the breathing becomes hurried, the pulse quickened, and sweat covers the body. Short intervals of ease follow the convulsive seizures, but growing muscular weakness, followed by complete paralysis of both motion and sensation, sooner or later ends in disablement or death.

ACUTE MYELITIS—INFLAMMATION OF THE SPINAL CORD

The causes which give rise to inflammation of the membranes of the cord are also responsible for inflammation of the cord itself, and mostly affect both structures in varying degrees at the same time.

Symptoms.—At the onset of the disease more or less stiffness is observed in the spine. The animal, when made to turn, does so in a wide circle. Firm pressure over the spine occasions pain. The hind-limbs are

repeatedly moved and sometimes strike the ground, or they are shaken as if to detach something objectionable adhering to them. Sensibility becomes diminished, and a rolling movement behind is observed when the animal attempts to walk. Muscular paralysis of the parts behind the seat of disease soon follows, and the patient falls to the ground unable to rise. The bladder now may fail to empty itself and become distended with urine. The fæces escape involuntarily in consequence of paralysis of the muscle (sphincter ani) which closes the anus. The bowels are constipated, but there is little, if any, rise of the bodily temperature. The farther forward the disease exists in the cord the more extensive will be the paralysis. When in the region of the neck the fore-limbs as well as the hind will become disabled, and the muscles of respiration will at the same time be involved, and occasion great difficulty of breathing and more or less disturbance in the action of the heart.

These affections of the spinal cord and its membranes usually become complicated with some rapidly destructive lung disease, or with inflammation of the bladder or kidney disease, to which the victim sooner or later succumbs. Should he escape these immediately fatal affections he remains paralysed and useless. Little, therefore, is to be expected from treatment of an animal so affected, and both humanity and economy will be best served by his immediate destruction.

PARALYSIS

By paralysis is understood a loss of power in the muscles to contract, and consequently greater or less impairment of voluntary motion. There is also a second form of paralysis, by which a part may be deprived of the sense of feeling. The former constitutes paralysis of motion, the latter paralysis of sensation.

They frequently occur together, but when this is so the loss of power usually exceeds that of sensation. Each may exist alone. The more common of the two as separate ailments is paralysis of motion.

Paralysis is not a disease, but a symptom of some disorder going on either in the brain or spinal cord, or the nerves connecting them with the paralysed part. If for any reason the brain fails to develop and to give out voluntary impulses, the influence of the will ceases to act upon those parts over which it ordinarily exercises control.

The nerves, although healthy in themselves, receiving no nervous force from the affected centre, become incapable of exciting muscles to contract.

On the other hand, the brain or nerve centre may be perfectly free from disease, but owing to some pressure or disease in the course of the nerves

the impulses developed by the healthy brain fail to travel along the diseased nerves, with the result that paralysis ensues in the part to which they are distributed.

The nerve centres and the nerves are liable to become disabled from a number of diverse causes. Lack of nourishment, the consequence of insufficient blood supply; certain poisons introduced from without or formed within the body, such as lead or the accumulation of urinary or biliary products in the blood; mechanical injury or pressure; rupture of blood-vessels in or upon the brain; the formation of tumours; inflammation and its consequences, are all found to produce paralysis at one time or another. From what has been stated it will be seen that paralysis may originate—(1) in the brain (cerebral), (2) in the spinal cord (spinal), (3) in the nerves connected with the one or the other (peripheral paralysis). Hence it follows that the disease presents a considerable variety of forms, of which only those of the more common kind will be considered here.

HEMIPLEGIA

In this form of paralysis one lateral half, the right or the left side of the body, is involved. It is a rare affection in the horse, but in man it is one of the most common forms of the disease, and usually appears suddenly in what is commonly known as a "stroke". The parts affected in hemiplegia are the fore and hind extremity, the muscles of the face, especially those of mastication, and the tongue on one side.

The loss of power may either be complete or incomplete, according to the intensity and extent of the cause, which commonly arises out of rupture of the vessels of the brain, with more or less escape of blood into the tissues of the organ.

Symptoms.—Hemiplegia is usually sudden in its onset. The affected animal falls to the ground in a more or less unconscious condition, and the limbs on the paralysed side are incapable of movement. In a case quoted from M. Gerard by Percival the sensibility of the left, the affected side, proved extremely acute. The lips and ala of the nose were drawn to the right side, the contrary to that to which the head and neck turned. A blowing noise was made by the air in its passage through the nostrils. The left ear was paralysed and the tongue distorted. When oats were laid before the horse it seized them with the right side of the mouth, the left remaining motionless. There was great difficulty in mastication, and some of the food was not swallowed, but became lodged between the cheek and the molar teeth. In feeding, the horse plunged its muzzle into the middle of its food and opened its mouth wide. In drinking,

its mouth was thrust deeply into the water. It could walk, but could hardly sustain itself after but a short exercise. On the fourth day the animal was unable to stand, sank down, and after several ineffectual struggles to rise, rolled over and lay upon its right side. Its pulse and respiration remained undisturbed. It died on the seventh day.

PARAPLEGIA—SPINAL PARALYSIS

Paraplegia indicates some disorder of the spinal cord, and consists of paralysis of the posterior half (more or less) of the body. The extent of the disablement will depend upon the seat of the disease, being greater in proportion as it is situated in a forward direction. Injury affecting the spinal cord in the region of the back or loins would paralyse the hind-quarters equally or unequally, but if it occurred in the neck, the fore and the hind limbs also, and the rest of the trunk behind the damaged cord, would also be deprived of the power of motion. Paraplegia in the horse is most commonly the result of injury inflicted on the dorsal or lumbar portion of the cord or its membranes, as when from some cause the latter become thickened and unduly press upon the former, or when they contain large quantities of fluid as the result of injury.

Bony growths projecting inwards from the spine sometimes press upon the cord and cause paralysis, or the same results may follow dislocation of the vertebræ.

Rarely spinal paralysis is due to causes originating in organs quite away from the spine, as when mares suffer during œstrum, or foals in consequence of worms in the bowels. This is termed "reflex paralysis", a form of the disease from which animals affected frequently recover. Here uterine irritation in the one case, and intestinal irritation in the other, is the cause of the failure of the spinal cord to innervate the muscles.

Symptoms.—In paraplegia there is more or less complete paralysis of the hind-quarters. When it is complete the animal occupies a recumbent posture and is unable to rise. When the skin of the paralysed region is pricked with a pin there is usually no sign of feeling, but in some instances the paralysis may be almost exclusively that of motion, while sensation remains intact, in which case the prick will be felt and expressed by the animal's movements in front. The urine may be discharged involuntarily, and the fæces too may escape in consequence of paralysis of the sphincter ani.

In incomplete paraplegia the hind-quarters roll from side to side, the animal crosses his hind-limbs, sometimes trails the toes, or knuckles over

with the fetlock joints. Movement aggravates the symptoms, and may cause the animal to fall, when more or less difficulty or complete inability will be experienced in rising.

Paraplegia in the horse, save when arising out of reflex causes, offers very little encouragement to treatment. Injury to the brain or cord of a paralysing nature seldom yields to medicine. In cases of a slight character it may be desirable to administer a dose of physic, to apply hot cloths over the loins, and to place the animal in slings or on a good bed of peat-moss, and later to administer iodide of potassium and nux vomica for two or three weeks and apply a blister along the back; but these are cases which should be promptly placed under the care of a qualified person.

PERIPHERAL OR LOCAL PARALYSIS

When paralysis is confined to muscles supplied by a particular nerve it is said to be "peripheral". The most common example of this form of the malady is that in which the seventh nerve is involved. The seventh nerve after leaving the brain emerges from the cranium through a canal in the

Fig. 180.—Facial Paralysis. A, Partial. B, Total.

petrous temporal bone, and on reaching the surface passes underneath the joint formed by the lower jaw and the temporal bone, and then over the cheek, where it gives off branches to the muscles of mastication, the nostrils, and the lips.

Injury to this nerve gives rise to paralysis of the muscles of the face, hence it is termed "facial paralysis". It may occur on one side, as is mostly the case, or both nerves may be simultaneously affected.

Causes.—Facial paralysis may result from injury to the nerve as it

passes through the canal in the temporal bone. This may be the result of disease of that bone, or of some effusion into the sheath of the nerve from inflammatory conditions.

Injury to the nerve after leaving the canal is the more common cause, such as blows beneath the ear when rolling, or being cast, or from other causes. Pressure from tumours or abscesses, or inflammatory swelling in its course, will also produce it.

Symptoms.—Where a nerve is paralysed the angle of the mouth on the sound side is drawn upward, while that on the paralysed side is lowered. The lips hang loose and pendulous, the eye cannot be closed, the nostril of the affected side cannot be dilated, the cheek is flaccid and has lost its firmness to the touch. In feeding, the patient seizes his food with the teeth instead of gathering it up with his lips. In drinking, the mouth is pushed into the water for some distance, and during mastication food falls from the mouth on the paralysed side.

Treatment.—When due to abscess or inflammatory swelling hot fomentations and poultices should be applied to the affected part.

If possible the abscess should be laid open and emptied, so as to remove the pressure on the nerve. This should be followed by iron tonics and nux vomica to restore the lost power to the muscles, and, if necessary, the application and repetition of iodine blisters. Where a tumour or inflammatory swelling exists, a purgative followed by iodide of potassium in full doses should be given.

CEREBRO-SPINAL MENINGITIS

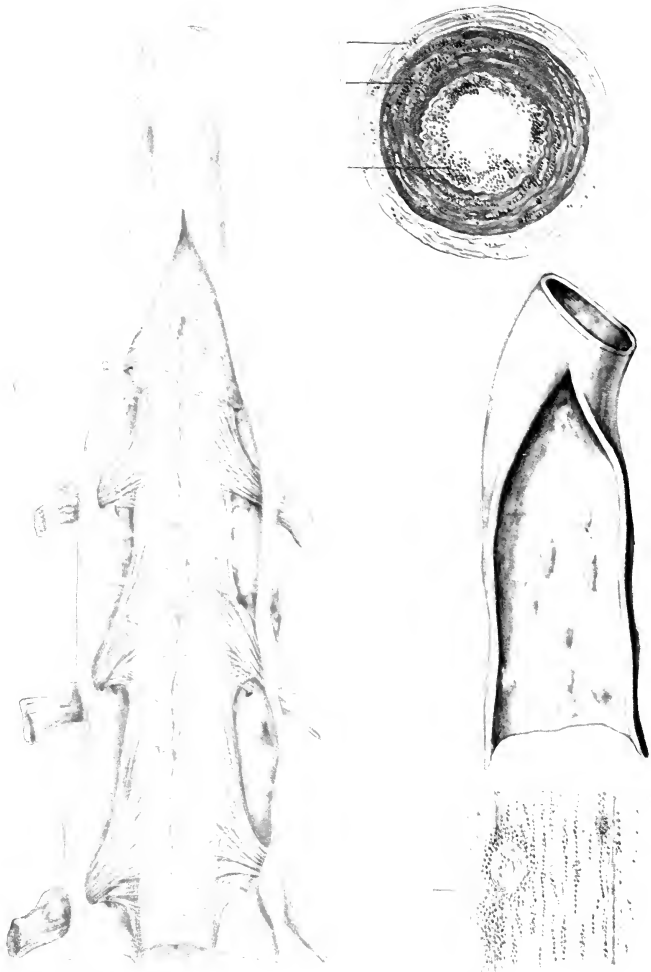
A fatal affection among horses implicating the spinal and cerebral membranes appears to have been known for a long period in various parts of the world. In the United States of America cerebro-spinal meningitis is recorded to have been investigated in 1850. In Germany it was known in 1865, and in Egypt ten years later. About the year 1881 a fatal form of paralysis attracted notice in this country, and Professor Axe described outbreaks which occurred almost simultaneously in Essex, London, and Norfolk. A peculiarity of the disease at the time was its limitation to certain parts of the year, the majority of cases occurring between the end of February and the beginning of May. Mares seemed to be more susceptible to the affection than horses, and animals of all ages were attacked. Climatic conditions did not appear to have any marked influence on the progress of the malady. When it was first recognized in 1881 the weather was cold and wet, but since then cases have been observed in the latter part of the summer during hot bright weather.

On the first appearance of the affection it was looked upon as a totally new malady which had probably been introduced from America.

Percival in his *Hippo Pathology* refers to a form of epizootic paralysis occurring on cold wet pastures in spring and autumn. Professor Axe mentions an article by Mr. Small in the *Veterinarian* for 1857 describing outbreaks of paralysis occurring in his district in that year. Other writers have also mentioned cases of the periodical occurrence of a form of paralysis in different parts of the country, and there is very little doubt that these cases were of the same character as those which have been recently designated cerebro-spinal meningitis.

With regard to the propagation of the disorder Professor Axe notices the communication of the disease to other animals than the horse. On this part of the subject he says:—"At the time when the disorder prevailed in the county of Essex, Mr. Ellis, veterinary surgeon of Maldon, resolved upon trying the efficacy of venesection. Several horses were consequently bled, and the blood removed from them was, contrary to instructions, thrown down in a yard adjoining the stables. During the day large numbers of sparrows were observed to partake freely of the clot, and after a short period to become paralysed in their wings, and unable to rise from the ground. On the following day a sow and a dog, which had also consumed some of the blood, were similarly affected, the latter so much so as to lead to his destruction. Several young pigs, offspring of the sow referred to, were at the same time seized with convulsive twitchings of the voluntary muscles, accompanied by a greater or less degree of paralysis. These latter animals, it should be mentioned, had not partaken of the blood of the horse, but were at that time subsisting exclusively on the milk of the dam."

Symptoms.—Indications of the disease in the majority of instances appear suddenly, but in other cases before there is any appearance of paralysis the animals show some premonitory signs of drowsiness, unsteadiness in their movements, catching the toe in the ground in walking. More commonly, however, without any warning the affected horse is found down and almost incapable of moving. In many cases the loss of power is apparent in the posterior half of the body, and during the progress of the affection nearly all the muscles of motion are involved. Sometimes the loss of power is particularly marked in muscles connected with swallowing, so that the animals cannot take fluid or solid; in other instances the power to eat and drink remains, while paralysis gradually extends over the body. In the advanced stages of the disease excitement is frequently present, alternating with spasmodic contraction of some of the muscles. The excitement may be followed by total loss of consciousness, or it may be



exaggerated and end in frenzy. These symptoms usually indicate that a fatal termination is at hand. During the course of the disease the temperature is but little affected, and, excepting when complications arise, the pulse and respiration are nearly normal. On post mortem examination it has been found that the membranes of the brain and spinal cord are charged with blood, and effused blood and serum are frequently found on the brain and spinal cord. The digestive and respiratory organs, and also the spleen and kidneys, show considerable changes in their texture.

No satisfactory explanation has been given of the origin of the disease. It has been looked upon as infectious, and recent experience of the malady goes to prove pretty conclusively that it is so. The fact of its recurrence occasionally and under very different conditions is sufficient in itself to prove that it is not due to any of the ordinary causes. Whatever the cause may be, it is quite certain that it only exists at intervals, and also that it affects a considerable number of animals in the district in quick succession. The cessation of the disease is sometimes as sudden as its appearance.

Treatment.—Of the different plans of treatment which have been tried none has proved so successful as to claim any pre-eminence. Laxatives, cold applications to the head, and in cases where muscular spasms in the neck, for example, are present, injections of morphine have been tried with partial success.

For the prevention of the spreading of the affection it is desirable to remove healthy animals from the immediate neighbourhood of the sick. Efficient cleansing and disinfection of the stables in which sick horses have stood must on no account be neglected, and a complete change of food is also desirable.

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5. THE ABSORBENT SYSTEM

This important system is composed of two parts, of which one is especially connected with the alimentary canal, whilst the other is widely distributed throughout the body. The former is named the *lacteal* system, the latter the *lymphatic* system. Both are composed of vessels presenting a general resemblance to those which convey the blood, and both ultimately discharge their contents into the thoracic duct, a tube which lies beneath the vertebral column and opens directly into the anterior vena cava. Both are interrupted in their course by glands—the lymphatic glands—of which those in relation with the lacteals are chiefly situated

in the abdomen at the root of the mesentery, whilst those connected with the lymphatics are found in the axilla, groin, neck, thorax, &c. The purpose of the lacteals, which have their origin in the intestine, is to absorb or take up the constituents of the food, in which they are assisted by the blood-vessels, whilst the lymphatics, which are everywhere distributed through the tissues of the body, reconduct to the larger blood-vessels the plasma of the blood which, having passed through the walls of the smaller blood-vessels, is in excess of the requirement of the tissues, and contains some of the products of their disintegration. As there are some differences between the lacteal and lymphatic vessels it will be expedient to describe them separately, though it must be borne in mind that they are only parts of the same system.

Fig. 181.—Sketch of the Lymphatic Vessels of the Fore-Leg (inner aspect)

The Lacteal System.—It is justifiable in common parlance to say, when an animal has eaten a hearty meal, that it has got its food inside it, but from a physiological point of view the food is still in reality outside the body, and no matter what quantity has been ingested it is unavailable for the nutrition of the tissues, or the production of heat or of nervo-muscular force, until it has been absorbed and assimilated. The starches, oils, and proteids which form the staple of the typical foods such as oats, barley, wheat, and other cereals are, in the raw state, incapable of passing through the walls of the intestine. In order that they may do so it is necessary that they should be rendered soluble, and this duty devolves on the various digestive secretions, that we have seen are poured forth from the numerous glands connected with the alimentary canal. By these juices starches are converted into sugars, oils into very fine emulsions or into soaps, and proteids into peptones, being in each case so modified that they are rendered capable of permeating the intestinal walls and the vessels ramifying upon them, and thus truly entering

the body and becoming first assimilated to and then incorporated with it.

The process by which the solutions of sugar, oil, proteids, or salts penetrate the wall of the alimentary tract is termed "osmosis", and can easily be shown by immersing a bladder filled with thick syrup in a jar of pure water, when a double current is immediately established. Some of the sugar solution escapes into the surrounding water, whilst a much larger proportion of pure water passing through the membrane to the syrup enters the bladder, distending it to the utmost and even to bursting.

The lacteal system may be said to commence in the delicate velvet pile-like processes or villi which line the whole of the small intestine, and which are shown in the accompanying wood-cut (fig. 182, 1).

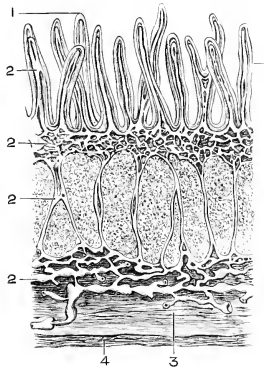


Fig. 182.—Section through the Small Intestine

[1] Villi. [2] Lacteal Vessels. [3] Muscular Coat. [4] Serous Coat.

Each villus contains a net-work of minute blood-vessels, not here depicted, surrounding a vessel of larger size (2), which is the lacteal. The latter, commencing near the summit in a blind extremity or a loop, passes down to the base of the villus, where it joins with others to form a net-work. These, after meeting together, emerge from the intestine as vessels of considerable size (2, 2), which accompany the blood-vessels of the mesentery, and, gradually uniting to form larger and larger trunks, terminate beneath the spine in a kind of sac or bladder (receptaculum chyli) which represents the hinder end of the thoracic duct. Whilst still contained within the villi, the lacteals are surrounded by muscular fibres, and when these fibres contract, the villi are changed in form from long finger-like processes into short projections, and the fluid they have absorbed, to which the term chyle (Greek *chulos*, juice) is applied, is consequently driven into the underlying net-work of vessels. The villi thus constitute small force-pumps which, though individually feeble, yet as a result of their numbers become important agents in the onward movement of the lacteal fluid. The vessels forming the net-work are provided with valves in their course which do not allow any backward current, but compel the fluid absorbed to move on towards the

receptacle into which it is to be poured. During fasting the lacteals only contain a clear fluid, and were on this account long overlooked. It is only after the consumption of oily foods or of some such fluid as milk that they present the white appearance which has led to the name of lacteals (Latin *lac*, milk) being applied to them.

Although the lacteals are highly important agents in the absorption of the soluble constituents of the food, the part played by the blood-vessels which ramify on the wall of the alimentary canal must not be overlooked. In the lower Vertebrata, as in fishes, no lacteals exist, and therefore all materials absorbed must be taken up through the walls of the blood-vessels in these animals, while it is obvious that the presence of a swift current of a thick fluid like blood on one side of the vascular wall must constitute a favourable condition for the absorption of a thinner and more diffusible fluid from the other side.

The Lymphatic System.—This system commences in the skin, and in the little spaces between the elements of the tissues in almost all parts of the body. It can be easily demonstrated by means of injections, for if a needle with a fine bore be plunged into the skin or into the muscles, and mercury or warm solution of gelatine holding some colouring material in suspension, as vermilion or Prussian blue, be forced through it with syringe, a beautiful and very close net-work of channels comes into view, which is quite distinct from the blood-vessels, and has no direct communication with them. The minuter blood-vessels, although they come into very close relation with the cells of glands and the fibres of muscle, do not actually touch them. There is always a layer of fluid, named lymph, between the two, so that, separating the blood from the actual constituents of every tissue, there are the wall of the blood-vessel and the layer of lymph outside that wall, as well as the walls of the vessels in which the lymph is contained, which indeed consists only of very thin cells. It is in the irregular spaces that are thus formed that the lymphatics arise. The spaces thus lined by flat cells soon, instead of being irregular, become tubular.

The Lymphatic Glands.—These bodies may be likened to oval or rounded masses of sponge, into which the lacteals convey chyle and the lymphatics lymph.

Fig. 183 represents the structure of one of these glands. The gland has an investing coat or capsule (7) which completely surrounds it. From the capsule fibrous strands (6) pass into the gland, dividing it off like partitions into spaces. The spaces round the circumference (or cortex) of the gland are of considerable size, and are more or less oval (3), while the spaces towards the centre (or medulla) are irregular in shape, and

smaller. The spaces are almost completely filled with masses of material, consisting of a net-work of very delicate connective tissue, in which white cells (4) of various sizes are entangled. This sort of tissue is called "adenoid", or gland tissue, from the Greek, *adeen*, a gland. But the masses of tissue do not quite fill the spaces. Between the outer surface of the mass and the wall of the space are channels (5), and the channel round one mass communicates with that of another, and those round the edge communicate with those in the centre, so that the gland might be looked upon as a mass of gland tissue broken up into numerous little clumps by a series of irregularly winding and communicating channels. The channels, moreover, are not perfect fair-ways. They are crossed and recrossed by spans of the delicate tissue of the gland, so that the whole structure becomes not unlike that of a sponge. Now the lacteal vessels join the mesenteric gland at the margin or outside (1), and pour their fluid contents into the channels there. From them the fluid filters its way to the channels of the centre, bathing and penetrating the gland tissue in its course, and finally joins other vessels (2), by which it is carried away from the gland. Through these comparatively free channels the chyle or lymph makes its way, easily entering the gland by the afferent, and escaping by the efferent vessels, and it then carries away from the gland but few leucocytes. When, however, the pressure of the fluid entering the gland is augmented, either by the process of digestion and the contraction of the villi in the case of the lacteals, or by active muscular movements in the case of the lymphatics, the lymph then percolates the substance of the gland and carries off with it by the efferent vessels large numbers of white cells, which are swiftly poured into the blood, and are believed to constitute one of the sources from which the blood corpuscles are recruited.

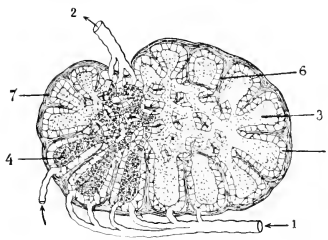


Fig. 183.—Section of Lymphatic Gland (diagrammatic)

[1] Afferent Lymph Vessel. [2] Efferent Lymph Vessel. [3] Cortical Substance. [4] Lymphatic Tissue. [5] Lymph Path. [6] Trabeculæ sent in from [7] Fibrous Capsule.

The main agents in effecting the movement of the lymph along its vessels are: (1) The force of the heart, which drives the plasma through the walls of the blood-vessels into the tissues; (2) the muscular movements of the body, generally aided by the valves present in all lymphatic

vessels and the minute muscles surrounding the lacteals in the villi. The pressure under which the lymph moves is very low, and it is discharged from the thoracic duct into that part of the blood vascular system where the pressure is lowest, namely, into the veins just before their entry into the right auricle of the heart.

When the outward movement of the lymph towards this point is impeded it accumulates in the vessels beyond the obstruction. This condition is more marked, and appears earlier if the obstruction be of such a nature as to affect the venous system as well as the lymphatic. The conditions known as œdema and dropsy are then established.

The composition of the lymph is very similar to that of the plasma of the blood, but it contains more water and less proteid matter. In the case of the horse there are about ninety-five to ninety-six per cent of water, and four or five per cent of solids, of which about three parts are albuminous or proteid substances, the remainder consisting of salts, the most abundant of which is common salt or sodium chloride.

The composition of chyle, consisting chiefly of the digested materials contained in the alimentary canal, varies with the nature of the food and the period of digestion at which it is examined. In the fasting animal it does not differ materially from the lymph, but, with an oily diet like milk, the proportion of fat undergoes great increase, and the lacteals become conspicuous by their white colour. After passing through the lymphatic glands, the lymph and chyle alike acquire the power of coagulating or clotting, though in both instances the clot is feeble and soft.

6. THE ORGANS OF CIRCULATION

THE BLOOD

From the earliest ages the blood has been held to be one of the most important constituents of the body, for it was natural, when death was seen to follow alike in animals and in man the infliction of a small wound (providing it opened a large vessel), to believe that as the blood drained away, the life itself was leaving the body. The practice of strict Jews of all periods of their history, acting up to the command: "But flesh, with the life thereof, which is the blood thereof, shall ye not eat", is evidence of the strong impress the constant association of loss of blood and of life has made on the mind of man. In many points of view it is indeed the river of life, for its flow supplies to all parts of the body the materials requisite for their

development, maintenance, and repair, whilst it is in addition charged with the vivifying oxygen it has absorbed at the lungs. On the other hand, it carries away from each part the products of disintegration and decay, and conducts them to the organs by which they may be severally eliminated from the system, the most important being the carbon dioxide, which is discharged at the lungs, and the urea, which is excreted or thrown off by the kidneys.

The blood of the horse, like that of other mammals, is of a deep-red colour, but brighter in the arteries than in the veins. The taste is mawkish, the odour faint but peculiar, and its reaction to test-paper invariably alkaline. Its specific gravity is about 1·061. It is clammy or slippery to the touch, and is remarkably opaque, transmitting but little light even in thin layers. It is in constant movement in the body. The quantity of the blood contained in a horse of average size is estimated to be about one-eighteenth of its body weight, or from 40 to 45 lbs., and it is considered that one-fourth is contained in the heart and larger blood-vessels, one-fourth in the muscles, one-fourth in the liver and intestines, and the remaining fourth in the other organs of the body. To the unassisted eye, the blood as it issues from a wound appears to be perfectly homogeneous, but when examined with a microscope of moderate power it is seen to be composed of a transparent fluid named the *plasma*, in which are suspended a large number of *corpuscles* (fig. 184). The existence of corpuscles in blood was first noticed in the hedgehog by the celebrated Italian physician and anatomist Malpighi in the year 1661, who thought they were globules of fat. They had previously been seen, in 1658, by the Dutch anatomist Swammerdam in the frog, but this investigator lost the credit of the discovery in consequence of his failing to publish his observations. The real merit of recognizing the corpuscles as constant and essential elements of the blood is due to another Dutch microscopist named Leeuwenhoek, who in 1673 observed and described them in man and many other animals. Great attention has been bestowed upon them

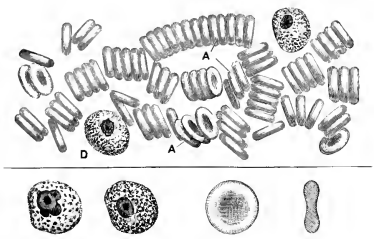


Fig. 184.—Blood Corpuscles

A, Coloured Blood Corpuscles adhering together in Columns (rouleaux). B, Coloured Corpuscle, showing concave surface. C, The same seen edgewise. D, E, F, Colourless Corpuscles.

by numerous observers, and three chief forms of corpuscles have been distinguished, named, respectively, red corpuscles, white corpuscles, and blood platelets.

The red corpuscles are pale-yellow circular discs, each resembling a coin, with edges thicker than the central part, and they are hence said to be biconcave. Their consistence is like that of moderately firm jelly. They have no nucleus. The transverse diameter is about $\frac{1}{3000}$ inch, and their thickness about $\frac{1}{12000}$ inch. They are a little heavier than the fluid in which they are suspended, and consequently have a tendency to fall to the bottom of the vessel when blood is removed from the body. This disposition to gravitate may be observed in the living animal, since if blood be gently drawn with a small syringe from the upper and lower parts of a large horizontal vein—like the external jugular or neck vein when the animal is recumbent—the number of the corpuscles contained in the specimen taken from the lower part of the vein will be found to be much greater than in the specimen taken from the upper part. The number of the corpuscles in the body of a horse is inconceivably great, but they may be counted in small quantities of blood which have been diluted with water, and it has been ascertained that there are no less than five or six millions in a cube $\frac{1}{25}$ inch on the side, which would be represented by a very small drop. In every hundred parts of the red corpuscles there are about seventy parts of water and thirty parts of solids, and if the solids be examined after the water has been evaporated, every hundred parts are found to consist of eighty-eight parts of hæmoglobin, ten parts of proteid substance of the nature of globulin, and two parts of lecithin and cholesterin. The hæmoglobin then is the most abundant, as it is the most important, constituent of the blood. It is to it that the blood owes its colour, and it possesses several remarkable properties. In the first place, it is one of the prime factors in the process of respiration, being the carrier of oxygen between the air and the tissues, combining with this gas in the lungs, but holding it with so weak a grasp as to surrender it to the tissues during the brief period that it is in proximity with them whilst traversing the more minute or capillary vessels. It is possible, although it has not as yet been proved, that hæmoglobin presents similar relations with carbon dioxide, taking up that gas in the tissues, in exchange for the oxygen with which it parts, and permitting its escape at the lungs in exchange for the oxygen it there absorbs. In this case it would serve as a carrier for both oxygen and carbon dioxide, its relations to each gas being governed by the degree of chemical affinity between the hæmoglobin and the gas and by the tension of the gas at the moment of exposure to it. Experiment has shown that every ten grains of hæmoglobin is able to

absorb about a cubic inch of oxygen gas. Its relation to carbon dioxide is less accurately known. Another peculiarity of hæmoglobin is its capability of forming crystals (fig. 185), some of the forms of which are here shown. The shape of these crystals in the horse is prismatic, as is usual in mammals. They are soluble in water. When by various means, such as freezing and again thawing, or by the addition of a little chloroform or ether to fresh blood, the hæmoglobin is rendered soluble in the plasma, the blood retains its colour, but becomes transparent like port wine. It is then named *laky blood*. The chemical composition of hæmoglobin is extraordinarily complex, one of the latest observers giving the formula—

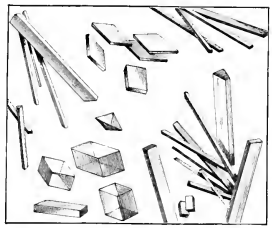


Fig. 185.—Crystals of Hæmoglobin

Carbon.		Hydrogen.		Nitrogen.		Oxygen.		Iron and Salts.
712	...	1130	...	214	...	245	...	2

The coloured corpuscles of the blood are constantly undergoing destruction, whilst new ones take the place of those that disappear. If such a renewal did not occur, every large loss of blood would inflict permanent injury on the animal, whereas experience shows that recovery soon takes place, even from abundant hemorrhage, temporary weakness being followed by perfect restoration to health and strength. As much as a gallon of blood may be withdrawn from the veins of a horse every month for several months together without impairing its health. The seats of formation, or the factories as they may be called, of the coloured corpuscles, appear to be the absorbent glands and their tributaries; the cancellous or spongy tissue in the heads of the long bones; the liver; spleen; thymus and thyroid bodies, and the gland-like tissue forming the sub-mucous coat of the alimentary canal. This difference in their place of origin may account for minor differences observed in the size, form, and colour of both the red and the white corpuscles. As the red corpuscles grow old they seem to enlarge, to lose their coloured contents, and either to break up in the vessels or to be seized upon in the spleen or other organ and consumed by large colourless cells named phagocytes.

Additional reasons for believing that their term of life is not a long one are, first, because great numbers of colourless corpuscles, some of which become coloured, are added to the blood after every meal; and, secondly, because if the blood of one animal be injected into the vessels of another,

the corpuscles, if capable of being distinguished, do not long persist in their new host.

The white or colourless corpuscles, named also leucocytes and lymphocytes, are present in the blood in much smaller number than the red. The proportion that they have to each other is not, however, a constant one, owing to the fact just stated, that a large accession to the numbers of the white corpuscles occurs after every meal. In the fasting state there is about one white corpuscle to every fifteen hundred red corpuscles, whilst after food the proportion may rise to one white to three hundred red, or even higher. Perhaps, taking the average, the proportion is about 1:500 or 1:1000.

The white corpuscles are spheroidal in form, dotted or granular in aspect, the granules they contain being in some instances coarse, in others fine, indicating in all probability a difference in their place of origin. By the action of various chemical substances a nucleus is brought into view, and sometimes two or three appear with great distinctness. Their diameter is about $\frac{1}{2500}$ inch. Their most remarkable character is the power they possess of undergoing changes of form and of moving from place to place (fig. 186). They act, in fact, as if they were parasites, living in the blood, but not necessarily confined to that medium. If a drop of blood be received upon the warmed stage of a microscope, and evaporation be prevented, they may be seen to exhibit perfectly independent movements, thrusting out little processes in this or that direction and withdrawing them again, exactly as an amœba would do if placed under the same conditions. By this means they are able to pass through the walls of the smaller blood-vessels and then wander freely through the outlying tissues, a process that is termed *diapedesis*.

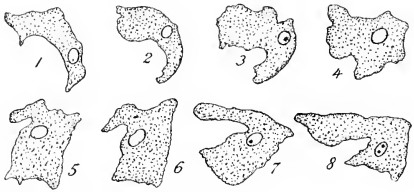


Fig. 186.—Colourless Blood Corpuscles, showing successive changes of outline during a period of ten minutes

The small corpuscles known as platelets are flattened, disc-shaped, or irregular particles, in regard to the nature of which little has been ascertained.

The plasma of the blood, in which the corpuscles are suspended, is a clear fluid having a specific gravity a little less than that of the corpuscles, which, therefore, when the blood is at rest, have a tendency to fall to the

bottom of the vessel. It contains a large proportion of nutritive material in the form of albuminous constituents, amongst which fibrinogen, serum-globulin, and serum-albumin are the most important, and it is also the solvent of many other bodies on their way to the tissues, or which result from the decay and disintegration of the various organs. Thus sugar, fats, urea, uric and hippuric acids, cholesterin and lecithin, and many salts are constant constituents. The following table shows the results obtained from the analysis of the blood-plasma of the horse by two excellent chemists, No. I being the result obtained by Professor Hoppe Seyler and No. II that of Professor Hammarsten.

Hoppe Seyler only examined the blood-plasma of one horse; Professor Hammarsten of three, of which he took the mean.

	No. I.		No. II.
Water	908·4	.....	917·6
Solids	91·6	.....	82·4
Total albuminous bodies	77·6	.....	69·5
Fibrin	10·1	.....	6·5
Globulin	—	.. ...	38·4
Serum albumin	—	.....	24·6
Fat	1·2		
Extractives	4	.....	12·9
Soluble salts	6·4		
Insoluble salts	1·7		

The Coagulation of the Blood. — When the blood is withdrawn from the body, it sets, coagulates, or clots, becoming converted from a fluid into a jelly. This process occasionally occurs in disease, whilst the blood is still contained within the vessels. It takes place in different animals with various degrees of rapidity; thus in the blood of birds less than a minute suffices to complete the change, while a quarter of an hour or twenty minutes may elapse before the blood of the horse becomes a solid mass. Violent muscular efforts made by the animal before the blood is drawn, or the rapid cooling of the blood, effected by surrounding the vessel into which it is drawn with ice, retard coagulation almost indefinitely. If the process of coagulation be carefully watched, it will be seen that on account of the corpuscles being heavier than the plasma, they sink through that fluid, their descent being aided by their disposition to adhere together by their broad surfaces, forming rouleaux (see fig. 181), and so presenting their edges to the fluid. The white corpuscles, though heavier than the plasma, are lighter than the red, and hence form a thin layer on the surface of the latter, the whole being surmounted by a moderately thick layer of plasma. Whether this separation of blood into layers have taken place or no, the whole mass becomes first viscous and then solid, the difference resembling

that seen in the white of egg before and after boiling, or in gelatine before and after setting. The consistence of the clot is about equal to that of red-currant jelly. After the lapse of a few minutes a further change may be seen. The clot contracts, and minute drops of a clear fluid begin to exude from the surface. This is the separation of the serum from the clot; and, as the contraction continues for many hours, the clot is ultimately covered and surrounded by a layer of clear fluid of considerable depth. When the separation of the freshly-drawn blood into three layers has taken place, the contraction of the upper layer of plasma, being unhindered by the presence of corpuscles, causes the upper surface to be much depressed in the centre, and its colour being yellowish, such clot is spoken of as being "buffed and cupped". It is, of course, not observed when clotting has taken place too quickly for the corpuscles to sink through the plasma. Coagulation of the blood is believed to result from the breaking up into two parts of a proteid substance named fibrinogen, naturally existing in solution in the plasma. One of these parts is a globulin which, under the influence of a ferment existing in the white corpuscles, remains in solution; the other is fibrin, which immediately solidifies, forming a delicate net-work in the meshes of which the corpuscles are entangled, and which, subsequently contracting, squeezes out the serum. The calcium salts also play an important part in the process.

THE MECHANISM OF THE CIRCULATION

The blood, the characters of which have just been considered, circulates through the body by the agency of the heart and blood-vessels. The heart is a portion of the vascular system, consisting of a compact but hollow mass of muscle that acts rhythmically as a pump, and, owing to the presence of valves suitably placed, drives the blood in one constant direction through the body. It is placed in the thorax or chest, and is protected from injury by the breast-bone and the firm but elastic ribs and spine, and also owing to its being enveloped to a large extent by the spongy tissue of the lungs. It is enclosed in a tough membranous bag named the *pericardium*, lined internally by a serous membrane, the smooth and polished surfaces of which, moistened with the fluid they secrete, reduce friction to a minimum. The general course pursued by the blood is from the heart, through the arteries and their ramifications, named capillaries, onward to the veins, by which it is again conducted to the heart. Although in appearance single, the heart is really a double organ, the two parts being united for the sake of economy of space and material, and also to enable them to work equably and simultaneously.

One of these hearts, the right, forces the blood through the pulmonary artery to the lungs, from whence, by the pulmonary veins, it returns to the left heart. The right heart is therefore called the pulmonary heart,

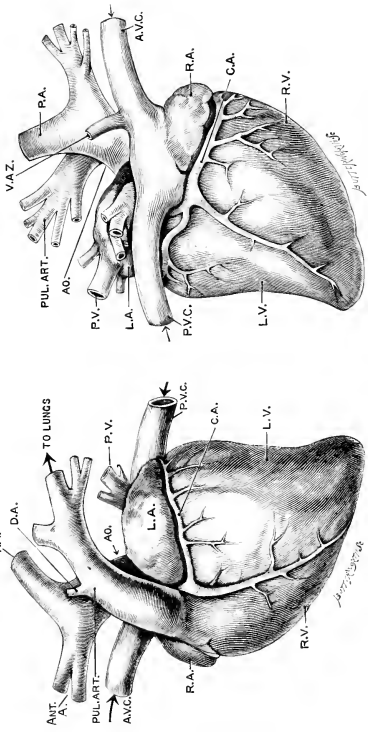


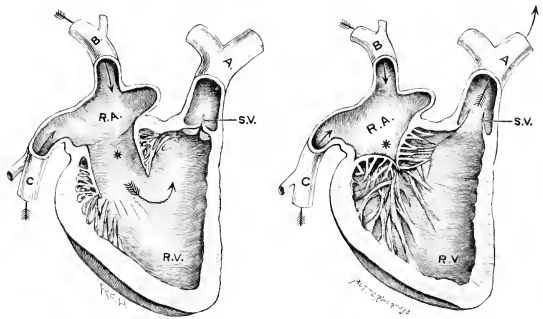
Fig. 188.—Horse's Heart, Right Side

Fig. 187.—Horse's Heart, Left Side

L.A., Left Auricle. R.A., Right Auricle. L.V., Left Ventricle. R.V., Right Ventricle.
AO., Aorta. ANT. A., Anterior Aorta. P.A., Posterior Aorta. PUL. ART., Pulmonary Artery.
C.A., Coronary Artery. A.V.C., Anterior Vena Cava. P.V.C., Posterior Vena Cava. P.V., Pulmonary Veins. V.AZ., Vena Azygos. D.A., Ductus Arteriosus Botalli.

and is the effective agent in the lesser or pulmonary circulation. The left heart is by far the stronger of the two hearts, and drives the blood through the aorta and its branches over the system at large, from whence it is returned to the right heart by two large veins (venæ cavæ). Hence

it has been named the systemic heart, and is the main agent in effecting the greater or systemic circulation. The right heart forces dark or venous blood, charged with carbon dioxide, through the lungs, where, becoming aerated by losing that gas and absorbing oxygen, it returns to the left heart as bright or arterial blood, and is distributed to the body generally. The heart as a whole weighs about 7 lbs. Its length is about 10 inches, and its width at the base about 7 or 8 inches. It is of conical form, the base being directed to the spine. The capacity of each cavity is estimated to be about $1\frac{1}{2}$ pint. The heart is composed of a form of muscular tissue intermediate between the striated and unstriated. The



Figs. 189 and 190.—Diagrammatic Views of the Heart, showing Valves open and closed

A, Pulmonary Artery. B, Posterior Vena Cava. C, Anterior Vena Cava. R.A., Right Auricle. * Auriculo-Ventricular Opening (open in the first figure and closed in the second). R.V., Right Ventricle. ➡ Course of Blood. S.V., Semilunar Valves (closed in the first figure, open in the second).

external or superficial layers run obliquely over both ventricles; the inner or deeper layers are confined to the right and left ventricles respectively. Each heart presents two cavities, an upper one, named the auricle, and a lower one, named the ventricle; so that there are two auricles and two ventricles, or four cavities in all. The right auricle receives the two venæ cavæ or large systemic veins above, and opens by a wide orifice into the right ventricle below, the aperture being guarded by the tricuspid valve. From the upper part of the right ventricle the pulmonary artery arises, the orifice of which is also guarded by the three semilunar valves. A similar arrangement exists on the left side. The pulmonary veins have no valves. They open into the left auricle above, and this communicates by a large orifice, guarded by the bicuspid valve, with the left ventricle below. From the left ventricle arises the aorta,

the orifice of which is also guarded by three semilunar or sigmoid valves.

The heart of the horse beats in health about forty times in the minute. The order of succession in the contraction is that the two auricles beat simultaneously, and then the two ventricles. Then there is a pause. The duration of the contraction is nearly the same as the pause. The contraction of the heart is named the *systole*. During the systole the whole heart becomes shorter and more conical in form, and twists a little upon its long axis towards the right. This contraction of the heart commences above at the opening of the great veins, which, being here surrounded by muscular bands, nearly close, and thus greatly impede, but do not altogether prevent, the backward flow of the blood from the heart into the venous system. From the great veins a wave of contraction instantly spreads over the auricles, driving the blood they contain through the auriculo-ventricular valves into the ventricles, which, already containing a little blood that has gravitated into them, are now distended to the utmost. There is no appreciable interval between the contraction of the auricles and that of the ventricles, but the wave of contraction continuing, without stay or stop, to spread from the auricles, makes the ventricles close upon their contents. The first effect of this is to raise the auriculo-ventricular valves and approximate their edges, and thus to prevent any return of blood into the auricles. The next is to propel the blood contained by the ventricles into the pulmonary artery and the aorta, for distribution through the lungs in the one case and over the general system in the other. In so doing the blood forces open the semilunar and sigmoid valves in these vessels and compels the whole mass of blood to move onwards. But as the column of blood resting on the valves just before they are forced open is quiescent, a brief period is required to overcome its inertia, and a remarkable provision against the jar that would otherwise be felt through the body, from the vigour and suddenness of the heart's systole, is found in the elasticity of the coats of the large vessels. Whilst, then, a part of the heart's force drives the

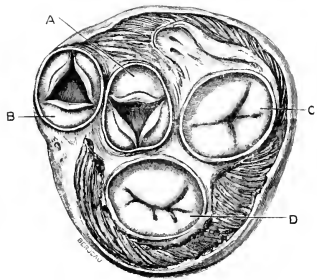


Fig. 191.—Section of the Heart, showing the Valvular Apparatus

A, Aorta. B, Pulmonary Artery. C, Mitral Valve. D, Tricuspid Valve.

blood forwards, a part is expended in dilating the arteries. As soon as the contraction is completed, relaxation immediately follows, and the heart passes into the state of commencing dilatation. The great vessels into which the blood has been forced now retract, and the first effect is to close the semilunar valves, and thus to prevent the return of the blood into the ventricles, whilst the next is to compel the onward movement of the blood in the vessels; the elastic reaction of the stretched walls restoring to the circulation during the diastole the force temporarily borrowed from the heart. The wave which is produced by the injection of blood into the vessels when the heart contracts is the pulse, but the closure of the semilunar valves is so sudden, and follows so immediately upon the contraction, that a reflex wave from the valves succeeds the main systolic wave and forms a part of the pulse. This is known as the dicrotic wave.

If the ear be applied to the chest two sounds may be heard to accompany the action of the heart; the first is dull and prolonged, the second is shorter, sharper, and ends abruptly. The first sound owes its origin mainly to the sudden tension of the auriculo-ventricular valves in the right and left hearts, but is almost certainly intensified by the muscular sound of the contracting ventricles. The second sound is exclusively due to the sudden tension of the aortic sigmoid, and pulmonary semilunar valves which guard the orifices of the aorta and pulmonary artery respectively. Both sounds are therefore valvular, and any rent, or inequality, or imperfection in the valves, permitting the blood to flow in the wrong direction, or causing friction, as in heart disease, causes alteration in the characters of the sounds easily recognized by the practised ear. The frequency of the beats of the heart is increased by exercise, by food, and by mental emotions. They are more frequent in the morning than at night, in the young than in the old, and in the female as compared with the male.

The Nerves of the Heart.—The heart continues to beat in an orderly and regular manner even when quite removed from the body, and in the process of development the speck which represents it in the young begins to beat rhythmically long before any nerves are formed. These circumstances show that its action is to a large extent independent of the great centres of the nervous system, whilst on the other hand the readiness with which the heart responds to disturbing conditions of the general system, in regard alike to the frequency and the strength of its beats, clearly indicates that it is under the control of certain nerves which can be demonstrated by anatomical as well as by physiological evidence to have intimate relations with it. The nerves distributed to the heart are derived from the spinal cord and medulla oblongata, as well as from

the sympathetic nerve. They have been divided into the accelerating and the restraining or inhibitory nerves. The accelerating nerves leave the spinal cord at the fore part of the dorsal region, and pass to the first dorsal ganglion of the great sympathetic chain, and after a short course are distributed to the heart. Stimulation of these branches causes the heart to beat more frequently.

The inhibitory or restraining nerves of the heart are derived from the medulla oblongata, and run in the vagus nerve. Their peculiarity is that, instead of causing contraction of the muscle to which they are distributed, they induce relaxation, so that when stimulated they stop the heart in diastole, that is, in a condition of relaxation; whilst when less strongly stimulated they cause it to beat more slowly. The effect is not, however, persistent, for even if the vagal branches continue to be strongly stimulated, the heart after a time recommences to beat more quickly and more strongly than before. The administration of belladonna, or of its active principle atropine, prevents the inhibitory effect from manifesting itself when the vagus is stimulated, and a similar action is exerted by curara and by nicotine. On the other hand, muscarin, a poison obtained from a mushroom (*Amanita muscaria*), seems to stimulate or intensify the inhibitory influence.

The heart is in unceasing movement day and night. Yet it has, like other muscles, its period of rest; for expenditure of force is only taking place during contraction, which occupies about one-half of the whole cycle of its action. It differs, therefore, from the ordinary muscles that are under the control of the will only in the circumstance that, instead of long spells of greater or less activity occurring alternately with the complete rest of sleep, its periods of work and rest have only short intermissions. The force it exerts is immense. If we estimate that the quantity of blood driven out of the left ventricle at each contraction is the low amount of 1 pint or pound, and that it is raised about 10 feet, which represents the blood pressure, the work done is 10 foot-pounds per beat. Taking the number of beats at 40 per minute, we have 400 lbs. raised 1 foot per minute, or 1 lb. raised 400 feet. If this be multiplied by the number of minutes in an hour, and of hours in the day, the surprising number of 576,000 foot-pounds, or more than 257 foot-tons, raised in twenty-four hours is obtained, which represents the work done by the left ventricle. The work of the right ventricle is estimated at one-third of this amount. The duration of one complete circulation of all the blood is about 27 seconds.

The Blood-vessels.—The first vessels into which the blood is driven by the beat of the heart are the *arteries*. These are tubes which conduct

it from the heart to all parts of the body. Of large size where they commence, the pulmonary artery from the right ventricle and the aorta from the left ventricle, they divide and subdivide almost always at an acute angle till they terminate in the capillaries. They possess three tunics or coats. The outer one, sometimes named the adventitia, is thin, strong, and resistant, and is composed of connective tissue, with some elastic fibres; in it run the small vessels and nerves which supply the walls of the vessels themselves. The middle coat differs according to whether a large or a small artery is under observation. In the larger arteries it is chiefly composed of elastic fibres, with a few unstriped muscular fibres interspersed amongst them. In the smaller arteries the elastic tissue becomes progressively less and less marked as they diminish in size, being replaced by the muscular tissue, which at last forms almost the whole thickness of the middle coat, the fibres for the most part running in a circular direction. The internal coat is composed of a sheet of elastic tissue with large apertures in it. It is lined by a layer of flat, endothelial cells, which are therefore in contact with the current of blood traversing the vessels. The nerves of the arteries form net-works in the substance of the vessel wall. The several coats of the arteries endow them with strength to enable them to resist the pressure of the blood, and also with elasticity and contractility. The elasticity is best marked in the large arteries, the contractility in the smaller ones. Both properties fulfil very important purposes. With each beat of the heart a pint or more of blood is suddenly injected into each of the great arteries. The shock and jar that this would produce through the entire system is almost entirely abolished by the great elasticity of the walls of the pulmonary artery and aorta. These vessels yield, and, greatly widening receive the new column of blood with facility. But on the instant of the heart ceasing to deliver the last drop of its contents, they immediately recoil. The first effect of the recoil is to close the semilunar valves, the next to cause the blood to move onwards and distend the next part of the artery in front. This having expanded, though to a

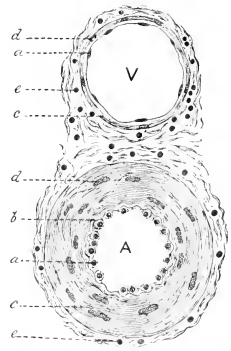


Fig. 192.—Transverse Section through a small Artery and Vein

A, Artery. V, Vein. *a*, Endothelial Cells with Nuclei. *b*, Elastic Layer of Tunica Intima. *c*, Tunica Media. *d*, Nuclei of its Muscular Fibres. *e*, Tunica Adventitia, showing Connective-tissue Fibres and Corpuscles.

less degree (for part of the blood in the arteries is escaping into the capillaries), now retracts on the blood within it, and as the arteries at each division present a larger area, and therefore a broader stream, whilst more and more blood is entering the great capillary sea, the interrupted current observed in the larger vessels, due to the intermittent action of the heart, is gradually converted in the smaller vessels into a uniform, steady, and continuous stream. Thus the pulse, which is very perceptible in the larger vessels, becomes imperceptible in the smaller ones. Subsidiary purposes for which the elasticity is useful are that it enables the limbs to be freely bent and stretched and otherwise moved without risk of rupture. It also enables the arteries to accommodate themselves to the considerable variations that occur in the absolute quantity of blood in the system. Lastly, the elasticity of the vessels reduces the chances of death by hemorrhage, partly by retracting the cut artery in its sheath, and partly by diminishing its calibre. The elasticity of the vessels is not a new or active force in effecting the circulation; it is passive, and represents the stored-up energy of the heart, which, during contraction, is expended in dilating the large vessels, and is given out again by them during the period of quiescence or relaxation of the heart.

The Pulse.—The pulse is the wave-like movement which traverses the arteries with each beat of the heart, and which is perceived when a vessel is slightly compressed with the fingers against an unyielding surface. The arteries, in health, are always distended with blood, as shown by the spurt which takes place when one is divided, and when a fresh quantity is injected into it by the heart.

The Contractility of the Arteries, unlike the property of elasticity, is feebly marked in the larger trunks and their primary branches, whilst it becomes more conspicuous in the smaller vessels. It is the means by which the supply of blood to the several organs is regulated in accordance with their condition of activity or repose. To take an example amongst many that might be given, the stomach during fasting receives a supply of blood sufficient to minister to the nutrition of the tissues of which its walls are composed. The vessels in this condition are contracted, and the colour of the organ is a pale pink; but after a hearty meal, when the process of digestion is in course of active performance, when gastric juice is being poured forth and absorption is proceeding, a much larger supply of blood is needed. Under the influence of certain (dilatator) nerves, by means of which the muscular tissue of the wall of the vessels is caused to relax, their calibre enlarges, a freer current of blood passes through them, and the whole organ becomes congested and of a deep rose-red hue. When the digestive process

is completed, and the blood-supply is no longer required, the contractility of the vascular walls comes into play again under the influence of another set of nerves (constrictor), chiefly proceeding from the sympathetic system. The vessels now contract, the mucous membrane becomes pallid, secretion and absorption cease, and the organ resumes its normal condition in the fasting state. A similar succession of events may be observed in every organ of the body that undergoes variations in functional activity, as in the brain during mental effort, and in the muscles during exercise.

Blood Pressure.—That when the skin is cut the blood spurts out is a proof that it is subject to pressure within the vessels. The Rev. Stephen Hales, the rector of Faringdon in Hampshire, was the first, at the beginning of the eighteenth century, to estimate what the degree of that pressure is in the living animal, and the animal he selected was the horse. He caused a mare to be tied down on her back, opened the main artery of the thigh, inserted into it a brass pipe the bore of which was $\frac{1}{6}$ inch in diameter, and to this, by means of another brass pipe, which was accurately adapted to it, he fixed a glass tube, of nearly the same diameter, which was 9 feet in length. On untying the ligature previously placed on the artery, he observed the blood to rise in the tube 8 feet 3 inches perpendicular above the level of the left ventricle of the heart. This experiment was an original and a highly instructive one. It has often been repeated, not only in the horse, but in many other animals. The result of many observations has been to show that the pressure of the blood in the vessels is equal to that of a column of *mercury* 150 to 200 millimetres, or from 6 to 8 inches in height. But Hales pushed his experiment a step farther. He proceeded to investigate the effects of loss of blood on the general blood pressure. He measured the blood as it ran out of the artery, and after each quart of blood had escaped he refixed the glass tube to the artery "to see how much the force of the blood was abated". This he repeated to the eighth quart, and then, its force being much lowered, he applied the glass tube after each *pint* had flowed out. He noted several remarkable circumstances. First, that as each quart of blood was removed the blood pressure sank considerably, but after the lapse of a minute, more or less, it again began to rise, and although it did not rise to its original level, yet it ultimately attained, on each occasion, a level higher than that to which it had previously fallen. This, there can be no reasonable doubt, was mainly due to the vessels accommodating themselves by virtue of their elasticity and their contractility to the reduced volume of their contents. Again, it was found that the decrease in the blood pressure was not strictly proportionable to the quantity of blood withdrawn; indeed, it sometimes rose above the level attained during the previous emission, which was probably due to variations

in the degree of contraction and relaxation of the muscles in the walls of the vessels, and in the strength of the contraction of the heart. The blood pressure immediately rose when the animal strained its muscles to get loose —an effect that was due to the muscular contractions, especially those of the abdominal muscles, forcing much blood towards the heart. In this celebrated experiment about a quart of blood was lost in making the several trials, and Hales estimated that about 17 quarts were lost in all before the animal died. Taking into account the blood that was obtained from the vessels after death, he considered that 44 lbs. was a low estimate of the total quantity of blood in the horse.

The cause of the blood pressure is twofold. On the one hand the heart is always engaged in driving into the vessels, which are already distended, or more than full, an additional quantity of blood; and on the other the current of the blood experiences great resistance to its onward passage in the smaller vessels, owing to their reduced diameter and the great friction that it consequently experiences in traversing them. The blood pressure would be much greater than it is were it not that, owing to the large number of the capillary vessels, the channel is greatly increased, the united area of the capillaries having been estimated to be eight hundred times greater than that of the aorta.

The rate of movement of the blood through the arteries is estimated to be about 1 foot 8 inches per second.

Prevention of Death by Hemorrhage.—Several circumstances concur to prevent the loss of life that would certainly occur, owing to the fluidity of the blood, when even a small vessel is divided. The first and most important of these is the almost complete closure of the opening of the tube by the contraction of the muscular tissue forming its walls. This tissue, as has been already stated, is most abundant in the small vessels which are chiefly exposed to such injuries. The closure of the vessel is of course aided by the elastic coat, which, being less and less distended, recoils as the blood pressure falls with the escape of blood from the system. Then the arteries are enclosed by a loose sheath, and when cut their proper walls retract to a considerable distance within it, leaving a narrow and tortuous passage, which impedes the exit of the blood. Again, the innermost coat of the artery is highly elastic, and has a tendency, when divided, to roll up within the artery, and thus to form a kind of valve, which is an additional obstacle to the escape of the blood. The coagulation of the blood of course plays an important part in arresting hemorrhage; a clot speedily forms in the loose tissue near the arterial or venous wound, which gradually stops up the opening and forms a plug for some distance up the vessel. Moreover, when much blood has been lost

the heart beats more rapidly, indeed, but much more feebly; and with faintness and loss of consciousness the current of blood almost ceases. Finally, the convulsions that are the precursors of death drive the few remaining drops to the heart, and, by stimulating it to contract, afford the last chance of life being preserved.

The Capillaries.—As the arteries proceed to the proper tissues of the body, they divide and subdivide till they are no longer visible to the unassisted eye, and they finally break up into minute vessels named capillaries, the size of which is tolerably uniform for each organ. These communicate freely with each other and form a mesh or web, the arrangement of which presents variations corresponding to the structure of the organ in which they exist, being ladder-like in muscle, tuft-like in the kidney, and basket-like round the lobules of fat and of glands.

The wall of the capillaries is formed of a delicate basement membrane with a lining of flattened cells (endothelium), or even of the cells alone. Through this thin wall the white corpuscles of the blood seem to be able to bore without leaving any rent behind them, just as a needle may be thrust through the wall of a soap-bubble and withdrawn without causing the bubble to burst. The corpuscles then become free, and can move about in the interspaces of the adjoining tissues; but whether they die there or re-enter the vessels is unknown. This process, in which the white corpuscles pass out of the vessels, is named *diapedesis*. The current of blood is not always the same in the same capillary vessel, the direction being dependent upon the increase of pressure behind, that is, on the arterial side, or the relief of pressure in front or on the venous side. In examining the circulation in the capillaries it will be seen that they are not large enough in many parts to admit two coloured corpuscles abreast, and they consequently follow each other in single file; but in the somewhat larger vessels the red corpuscles occupy the centre of the stream, whilst the white corpuscles roll lazily along at the margin in close contact with the inner surface of the wall of the vessel. It is in the play of the fluids within and without the capillary vessels that an important part of the processes of nutrition is transacted, the blood surrendering to the fluid which moistens their external wall the soluble materials for the nutrition of the tissues, whilst it takes up from that fluid the soluble products of the degeneration and decay of the tissues. The capillaries of the lungs are very large, and form a close net-work. Those of the brain are minute and less close. The average diameter of the capillaries may be taken to be a little larger than the diameter of the corpuscles of the blood of the same animal. The pressure of the blood in the capillaries is considerable, being capable of supporting a column of mercury about 1 inch in height. The

blood flows through them at the rate of about one twenty-fifth of an inch in a second.

The veins have thinner walls than the arteries, are more numerous than they, and have much greater capacity, containing, according to the estimate of Haller, about twice as much blood. They communicate with each other by large branches very frequently in their passage to the heart, and in structure very much resemble the arteries. The principal instance where veins do not convey the blood directly to the heart is the great portal vein, which conducts the blood from the intestines to the liver, and there breaks up into a second system of capillaries, which unite together again to form the hepatic vein; a similar arrangement occurs in the case of the kidney.

In the veins of the neck and limbs, however, differences are found in the form of numerous valves, usually arranged in pairs, and at tolerably regular distances from each other. These valves are composed of a reflexion of the inner coat, strengthened with some connective-tissue fibres, and near their base have also a small amount of involuntary muscle. The function discharged by the veins is to convey the blood back to the heart. The veins collectively, though there are a few exceptions, convey the blood to the heart, and run side by side with the arteries after which they are named. The radial artery is thus accompanied by the radial vein or veins, the brachial artery by the brachial veins. There are often two or more veins to one artery. The veins are more exposed than the arteries, as is seen in those of the neck, face, body, and limbs. Their capacity is greater than that of the arteries, and the blood flows through them with a uniform and continuous current, but more slowly, the velocity of the current being about 1 foot per second. They communicate freely with one another, and hence obstruction in any one vein is of less importance than in the case of an artery, since the flow of blood hindered or arrested in one channel of the former easily finds escape by another.

The Chief Arteries and Veins.—We may now, with advantage, take a short survey of the chief vessels that have their origin in the heart, and which are engaged in the distribution of the blood through the system. The large arteries rarely join each other as do the veins, and the blood which traverses them always pursues the same direction. The capillaries, on the other hand, freely anastomose or unite together, and the blood they contain sometimes runs in one, sometimes in the opposite direction, through them; and as many arteries open into the same capillary net-work, this arrangement effectively prevents the serious consequences that would result in the case of obstruction or division of an artery, unless, indeed, the artery injured is a very large one, and is the parent trunk of the several arteries which open into the same capillary plexus. If, for

example, the aorta in a rabbit is tied above its division into the two iliacs, thus depriving the lower limbs of their whole supply of blood, the legs soon begin to drag, and become permanently paralysed, though even then, if the limbs are kept warm and preserved from injury, by placing the animal on cotton-wool, a secondary circulation through collateral vessels above and below the point of ligature may in course of time become established, and the power and action of the limb be restored.

The pulmonary artery is a great trunk which arises from the upper and left side of the right ventricle. Its orifice is guarded by three semilunar valves (fig. 191, D), which are forced open at each contraction of the heart, but close during its relaxation, and then completely prevent the return of the blood into the right ventricle. It conducts the blood to the lungs, and after a short course divides beneath the trachea into a right and left branch, which accompany the respective bronchi to the lungs, where they break up into many branches, and terminate in the capillary net-work that surrounds the alveoli or air-cells. The pulmonary artery conveys impure or venous blood to be aerated at the lungs from whence it is returned, charged with oxygen and freed from carbon dioxide, by the pulmonary veins to the left auricle. Just before the pulmonary artery divides, an oblique cord (fig. 187, DA) runs from it to the posterior aorta. This is an obliterated blood-vessel named the "ductus arteriosus Botalli", which before birth transmitted the impure venous blood mainly returning from the head and fore extremities to the trunk and hind-limbs. Immediately after birth, and as a result of the change in the circulation and the entrance of air into the lungs, this vessel ceases to convey blood and undergoes atrophy, becoming an impervious band.

DISTRIBUTION OF THE SYSTEMIC ARTERIES

Excepting as regards the lungs, all the arteries distributed over the system have their origin in the aorta (fig. 193). This vessel, the largest in the body, arises from the base of the heart, where it is continuous with the left ventricle, from which it is separated by the semilunar valves. It receives the blood discharged from that cavity at each contraction.

The Aorta is a very capacious but short vessel, measuring only from 2 to 3 inches in length. After leaving the ventricle it soon divides into two unequal parts—the anterior and the posterior aortæ; but before doing so it gives off two vessels, whose branches enter the substance of the heart for the nourishment of its tissue. These are the right and left *coronary arteries*.

Anterior Aorta.—This vessel, the smaller of the divisions of the

DISTRIBUTION OF ARTERIES I

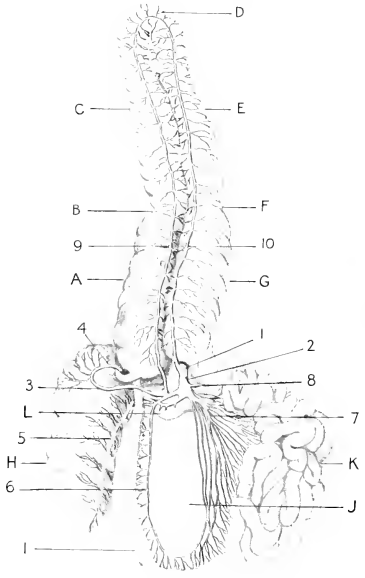
Anterior Mesenteric Artery

A. First part of colon.
B. Suprasternal flexure.
C. Second part of colon.
D. Pelvic flexure.
E. Third part of colon.
F. Diaphragmatic flexure.
G. Fourth part of colon.
H. Cæcum.
I. Ilium.
J. Great mesentery.
K. Small intestine.
L. Duodenum.

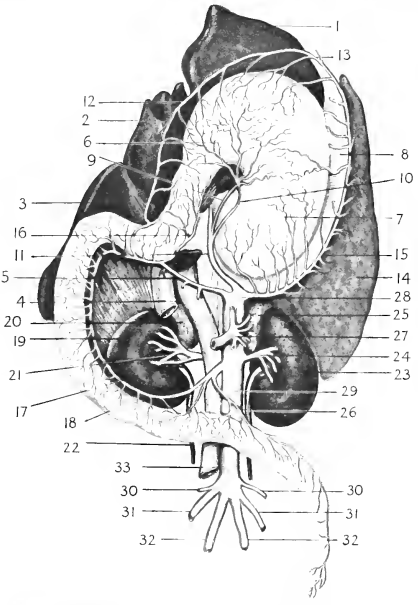
1. Posterior aorta.
2. Anterior division of anterior mesenteric artery.
3. Right division of anterior mesenteric artery.
4. Artery of the arch of the cæcum.
5. Superior cæcal artery.
6. Ilio-cæcal artery.
7. Bunch of arteries to small intestine
8. First artery to single colon.
9. Right colic artery.
10. Left or retrograde colic artery.

Arteries of Stomach, Spleen, Liver, Kidneys, &c.

1. Left lobe of liver.
2. Middle lobe of liver.
3. Right lobe of liver.
4. Vena porta.
5. Hepatic artery.
6. Right sac of stomach.
7. Left sac of stomach.
8. Gastric splenic omentum.
9. Anterior gastric artery.
10. Posterior gastric artery.
11. Gastric artery.
12. Right gastro-omental artery.
13. Left gastro-omental artery
14. Spleen.
15. Splenic artery.
16. Pyloric artery.
17. Duodenal artery.
18. Duodenum.
19. Right kidney.
20. Suprarenal capsule.
21. Right renal artery.
22. Ureter.
23. Left kidney.
24. Left renal artery.
25. Left suprarenal capsule.
26. Left ureter.
27. Anterior mesenteric artery.
28. Coeliac axis.
29. Posterior aorta.
30, 30. Circumflex iliac arteries.
31, 31. External iliac arteries.
32, 32. Internal iliac arteries.
33. Posterior vena cava.



Anterior mesenteric artery.



Arteries to stomach, spleen, liver, kidneys, &c.

DISTRIBUTION OF THE ARTERIES—I

common aorta, is about 2 to $2\frac{1}{2}$ inches in length. On leaving its parent trunk it passes in a forward direction beneath the trachea or windpipe, and soon divides into two unequal branches, one passing to the right and the other to the left. The right one is the *arteria innominata*, and the left one the *axillary* artery. The right branch is much the larger of the two, for in addition to giving blood to the fore-limb and the anterior part of the trunk, like its fellow, it also supplies the head by means of a large branch, the *cephalic artery*. Each of these vessels, on leaving the anterior aorta, gives off eight branches of considerable size, as follows:—

1. Dorsal.
2. Superior Cervical.
3. Vertebral.
4. Internal Thoracic.
5. External Thoracic.
6. Inferior Cervical.
7. Supra-scapular.
8. Subscapular.

These vessels divide and subdivide in their course, and furnish blood to the withers, the neck, the shoulders, and the walls of the chest. The vertebral artery requires special notice, inasmuch as it courses along the neck, partly enclosed in small bony canals in the transverse processes of the six anterior cervical vertebræ. In its course it supplies many branches to the deep cervical muscles, and others which enter the spinal canal and are distributed to the spinal cord.

After giving off the arteries above-named, the axillary descends along the inner aspect of the upper arm, where it takes the name of the *brachial* or *humeral artery*.

Brachial or Humeral Artery.—This vessel descends on the inner aspect of the humerus and distributes branches to the muscles of the upper arm and other adjacent structures, the larger and more important of which are—

1. Prehumeral, or Anterior Circumflex.
2. Deep Humeral, or Humeralis Profunda.
3. Ulnar.
4. Artery of the Biceps.

On nearing the upper extremity of the radius or forearm the humeral artery divides into two unequal branches, the anterior and posterior radials: one, the smaller anterior radial, passes in a forward direction, and after distributing several small vessels to the extensor muscles, courses its way down the front of the leg as far as the knee, to which it furnishes numerous small branches.

The Posterior Radial, much more voluminous than the anterior, descends on the inner side of the radius or forearm, where it is covered by the flexor metacarpi internus muscle. In its course along the limb the *posterior radial* gives off branches to the elbow-joint, the flexor and extensor muscles, the skin, and also to the knee-joint. On reaching

the latter it divides into two: (1.) The small Metacarpal Artery. (2.) The large Metacarpal Artery. The former, superficially placed at first on the inner side of the knee, dips down behind the head of the canon-bone. It crosses to the outer side by passing between the suspensory and the subcarpal ligament. Here it anastomoses with a branch from the supracarpal arch to form the subcarpal arch, which then proceeds to give off the anterior and posterior interosseous arteries, which supply blood to the structures behind and in front of the canon-bone, to the bone itself, to its periosteum or covering, and to the flexor tendons.

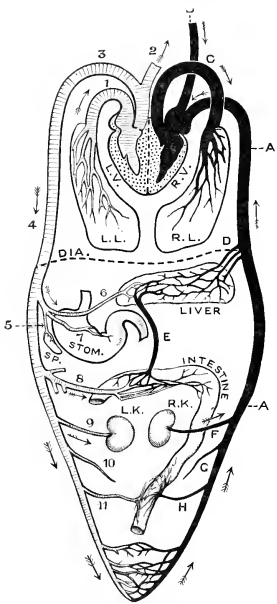


Fig. 193.—Diagram of Circulation

A, A, Posterior Vena Cava. B, Anterior Vena Cava. C, Pulmonary Artery. D, Hepatic Veins. E, Vena Porta. F, Renal Vein. G, Spermatic Vein. H, Posterior Mesenteric Vein. [1] Pulmonary Vein. [2] Anterior Aorta. [3], [4] Posterior Aorta. [5] Splenic Artery. [6] Hepatic Artery. [7] Gastric Artery. [8] Anterior Mesenteric Artery. [9] Renal Artery. [10] Spermatic Artery. [11] Posterior Mesenteric Artery. L.K., Left Kidney. R.K., Right Kidney. DIA., Diaphragm. R.L., Right Lung. L.L., Left Lung. R.V., Right Ventricle. L.V., Left Ventricle. STOM., Stomach. SP., Spleen.

The large metacarpal artery descends on the inner side and somewhat in front of the flexor tendons until it reaches the sesamoid bones, where it divides into two parts, the internal and external digital arteries. These vessels pursue a downward course over the fetlock-joint, giving off branches before and behind to the tissues in the region of the pastern, and finally, entering the foot, they break up into a number of vessels and supply the frog, the coronary cushion, the sensitive laminæ, the coffin-bone, and other parts contained within the hoof. This artery is situated between the plantar nerve behind and the internal metacarpal vein in front.

Cephalic Artery.—This vessel, as we have previously pointed out, is a branch of the right axillary and runs forward beneath the trachea until it reaches the entrance to the chest, where it divides into a right and left carotid artery.

Carotid Arteries.—These vessels ascend the neck, one on the right and the other on the left side of the trachea, in company with two important nerves, the vago-sympathetic and the recurrent. On reaching the larynx, they each divide into three vessels—the external carotid, the internal carotid, and the occipital.

1. **The External Carotid** supplies on each side the external parts of the head. It runs beneath the parotid gland, behind the angle of the jaw, and distributes its branches to the muscles of mastication, the submaxillary and sublingual salivary glands, the tongue, the palate, the pharynx, the lips, the ear, the teeth of the upper and lower jaw, and parts of the eye and membranes of the brain.

2. **The Internal Carotid** ascends on the outer side of the guttural pouch and enters an opening (*Foramen lacerum*) at the base of the skull; while on the floor of the cranium it unites by a cross branch with its fellow on the opposite side, and forms with it an arterial circle (Circle of Willis). It sends branches upward into the substance of the brain at different points, and thus ministers to its nourishment. The chief vessels of the brain are: The Anterior Cerebral. Middle Cerebral. Anterior Communicating. Posterior Cerebral. Posterior Communicating. Anterior Cerebellar. Posterior Cerebellar.

3. **Occipital Artery.**—This artery, given off by the carotid, is the third division. It passes up to the atlas or first bone of the neck, and after giving off the retrograde, mastoid and occipito-muscular branches to the small muscles of the poll, enters the spinal canal by an opening in the first vertebra, and divides into the cerebro-spinal and occipito-muscular branches. The former on entering the spinal canal divides into two branches, one passing backwards along the spinal cord, and the other, going into the cranium, joins with its fellow on the opposite side to form the basilar.

Posterior Aorta.—This is a large vessel of considerable length situated immediately beneath the spine, along which it runs from the seventh or eighth dorsal vertebra as far back as the sacrum. It is the largest division of the common aorta, and in the first part of its course describes an arch backward, termed the aortic arch. The anterior portion of the vessel is situated within the chest, and is hence distinguished as the thoracic aorta, while the posterior segment occupies the abdomen, and is known as the abdominal aorta. It is, however, one continuous vessel, and these different terms are only used to denote its anatomical relations. As it proceeds backwards it passes from the chest into the abdomen through the *hiatus aorticus*, an opening between the two pillars of the diaphragm.

The posterior aorta in its course beneath the spine gives off a number

of branches, some of which are distributed to the walls of the chest and abdomen, while others go to the various organs they contain. The former set include: (1) 13 posterior *intercostal* vessels, which run downward between the ribs and give off branches upward to the muscles of the back and to the spinal cord. The first intercostal artery is derived from the superior cervical artery; the second, third, and fourth from the subcostal branch of the dorsal. (2) *The phrenic*, a branch going to the diaphragm or midriff. (3) Branches to the muscles of the loins.

The second group comprise: (1) The bronchial arteries to the air-tubes and œsophagus or gullet. (2) The cæliac axis, a short thick vessel, which, after leaving the under surface of the aorta, divides into three unequal branches—

(*a*) The Splenic. (*b*) The Gastric. (*c*) The Hepatic

The first goes to the spleen, the second to the stomach, and the third to the liver. A little farther back it gives off (3) the great mesenteric artery, a short vessel of considerable size, whose branches are distributed to the large and small intestines. The next to appear are (4) the renal arteries, two short thick vessels, which spring from the sides of the aorta and enter the substance of the kidney. Still farther back come (5) the *spermatic vessels*. These arteries, two in number, are of considerable length, and take a peculiar winding course downward to reach the testicles. In the female the uterine and ovarian arteries spring from this point, and, as their names imply, supply the uterus and the ovaries. Then comes the *small mesenteric*, whose branches are distributed to the posterior part of the large bowel, which is not supplied by the large mesenteric. Finally, the posterior aorta divides into two pairs of vessels, one pair going to the right and the other to the left. These are distinguished as—

1. The Internal Iliac Arteries. 2. The External Iliac Arteries.

The Internal Iliac Artery breaks up into several divisions, which convey blood to the organs within the pelvis—the bladder, rectum, prostate gland, as well as parts of the uterus and vagina in the female and the penis in the male. They are: (1) the two last lumbar arteries; (2) the internal pudic artery; (3) the lateral sacral artery; (4) the ilio-lumbar artery; (5) the gluteal artery; (6) the ilio-femoral artery; (7) the obturator artery.

The External Iliac Artery, on leaving the aorta, runs down the inner side of the pelvis in an oblique direction backwards and outwards. On reaching the anterior border of the pubis it enters the thigh and takes the name of the femoral artery. In its course it gives off the circumflex iliac artery, which is distributed to the flank and to the thigh. A small

DISTRIBUTION OF ARTERIES II

Arteries of Male Pelvis

1. Retractor penis.
2. Suspensory ligament of rectum.
3. Sphincter ani.
4. Rectum.
5. Vesiculæ seminales.
6. Urinary bladder.
7. Ureters.
8. Prostate gland.
9. Cowper's gland.
10. Vesico-prostatic artery.
11. Erector penis.
12. Suspensory ligament of penis.
13. Penis.
14. Posterior dorsal artery of penis.
15. Anterior dorsal artery of penis.
16. Vas deferens.
17. Epididymis.
18. Testicle.
19. Spermatic artery.
20. Subcutaneous abdominal artery.
21. External pudic artery.
22. Posterior abdominal artery.
23. Deep femoral artery.
24. Prepubic artery.
25. Obturator artery.
26. Umbilical artery.
27. Posterior aorta.
28. Second last lumbar artery.
29. Internal iliac artery.
30. Last lumbar artery.
31. Lateral sacral artery.
32. Gluteal artery.
33. Ileo-femoral artery.
34. Internal pudic artery.
35. Artery of the corpus cavernosum.
36. External iliac artery.

Arteries of the Brain

1. Anterior cerebral artery.
2. Middle cerebral arteries.
3. Anterior communicating arteries.
4. Internal carotid arteries.
5. Posterior communicating arteries.
6. Posterior cerebral arteries.
7. Bifurcation of basilar artery.
8. Anterior cerebellar arteries.
9. Basilar artery.
10. Posterior cerebellar arteries.
11. Cerebral branches of cerebro-spinal artery.

A. Cerebral hemispheres.

B. Cerebellum.

C. Olfactory bulb.

D. Optic commissure.

E. Pituitary body.

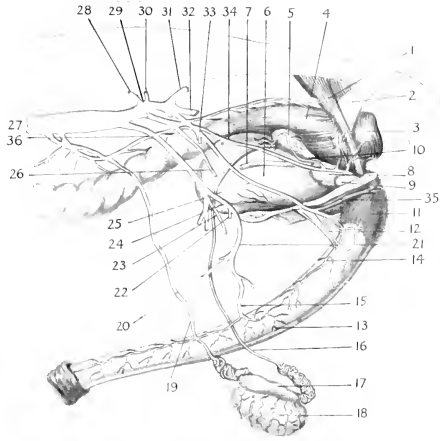
F. Corpus albicans.

G. Olfactory tract.

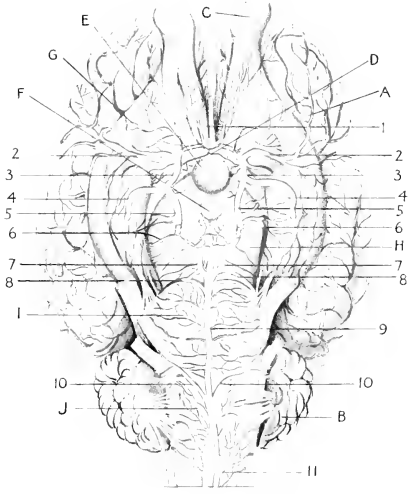
H. Crura cerebri.

I. Pons varolii.

J. Medulla oblongata.



Arteries of the male pelvis



Arteries of the brain

DISTRIBUTION OF THE ARTERIES II

branch goes to the spermatic cord, which in the mare goes to the uterus, and the prepubic artery, a vessel which divides into the posterior abdominal and the external pudic arteries.

The Femoral Artery extends from the os pubis above to the lower part of the femur, where its name changes to the *popliteal*. In its course downward it gives off several considerable branches, which are distributed to the muscles of the thigh.

The Popliteal Artery, a continuation of the femoral, lies behind the femoro-tibial articulation or stifle-joint, and in front of the popliteal muscle. After distributing small branches to the structures around, it divides into two parts—the anterior and posterior tibial arteries.

Anterior Tibial Artery.—This is the larger of the two, and, as its name implies, is situated in front of the tibia or second thigh, down which it passes beneath the flexor metatarsi muscle. On reaching the tibio-tarsal articulation or hock-joint it takes the name of the *great metatarsal artery*. In its course down the leg it gives off a number of branches to the tibio-femoral articulation and to the muscles in its course, especially those in front of the tibia.

Pedal or Great Metatarsal Artery.—This vessel is a continuation of the anterior tibial. It commences in front of the hock-joint, and passes obliquely outwards beneath the peroneus and the short extensor of the foot, to reach the furrow formed by the large canon and the outer splint-bone, along which it runs until nearing the fetlock-joint, where it passes inwards between the suspensory ligament and the large metatarsal bone, and divides into two branches—the right and left *digital arteries*. These traverse the sides of the phalanges or pasterns, and are ultimately destined to the foot.

The Posterior Tibial Artery lies deeply situated behind the tibia, and besides furnishing branches to the deep muscles of the leg it also supplies the nutrient vessel of the bone, and furnishes branches to the hock-joint. Finally it divides into the two plantar arteries.

DISEASES OF THE HEART

GENERAL CONSIDERATION OF THE PATHOLOGY OF HEART-DISEASE

It seems to be agreed among veterinary writers that diseases affecting the heart of the horse are either not so numerous as those which attack the heart of the human subject, or that they pass to a great extent unnoticed until an opportunity is afforded for a post-mortem examination.

Going back to the work of Gibson, who wrote in 1751, it will be

observed that after a description in detail of the structure and functions of the heart and large vessels, he dismisses the pathology of the organ in a short paragraph. "I have seen", he says, "the hearts of horses frequently opened; sometimes there happens, as in the human body, collections of matter within the pericardium. I have seen pollipusses in the great vessels, sometimes a mass of slippery fat, especially within the left ventricle of horses that have died suddenly, and sometimes the heart itself is preternaturally large."

Since the time of Mr. William Gibson, surgeon, knowledge has advanced, but even at the present day the subject of disease of the heart and large vessels is dealt with by veterinary writers in a very cursory manner.

In the last edition of Mayhew's work on the horse, edited by Mr. James Irvine Lupton, it is remarked that disease of the heart is characterized by various names in scientific books, as carditis, pericarditis, hydrops-pericardii, inflammation of the pericardium, &c. All such conditions, the writer observes, in the horse were discovered by examination instituted after death, when, unfortunately, all opportunity of observing symptoms had ceased. Veterinary science cannot distinguish one state from another while life exists. Mayhew goes on to state that "diseases of the heart in horses are incurable", and suggests that it is possibly on that account that "apparently little attention has been paid to the diagnosis and treatment of them". Remarking on the absence of characteristic symptoms, he adds that auscultation affords the surest means of detection. Any unusual sound, he says, being audible, the examiner may conclude that the heart is diseased. In further description of symptoms it is stated that "the visible signs are sometimes sufficiently emphatic to admit of no doubt"; the eye is expressive of constant anguish, the countenance is haggard, the pulse is feeble and irregular, and the heart-throbs are visible and frequent; they are to be seen as plainly on the right side as on the left. Regurgitation within the jugular veins is nearly always excessive, the blood often reaching almost to the jaw."

The difference between the estimated importance of heart-disease in man and the lower animals is emphasized by Mayhew, and indeed is urged in explanation of the comparative indifference with which these diseases have been regarded by the veterinary surgeon. The veterinarian is seldom called upon to treat heart-disease, and has not the same experience of diseases affecting this organ as has the physician, for the reason that man, even when suffering from an incurable ailment, must be treated, but the horse in a similar state is usually sent to the knacker; consequently it is from human medicine that the most valuable information has been received. These remarks are strictly correct, and fairly estimate the circumstances

which have enabled the members of the veterinary profession to recognize the clinical symptoms of some of the diseases of the heart of the lower animals, which they can now diagnose with almost absolute certainty, although it still remains true that the physician has enormous opportunities and facilities in the examination of the heart of the human subject which are not, and cannot, under any possible conditions, be possessed by the veterinary surgeon. The heart of the horse and other large mammalians is so perfectly covered by the bones and muscles of the upper part of the fore extremities that it is absolutely impossible to apply the stethoscope or the ear over every portion of the organ, as can be easily done in the human subject; further, the instrument cannot be employed with the same advantage as it possesses in the hands of the physician. Even in those parts which can be reached, the covering of hair interposes an obstruction which considerably alters and obscures the sounds which can be recognized, and it is on this account that the majority of veterinary surgeons content themselves with the application of the ear to the part of the animal which they wish to auscultate instead of using the stethoscope for the purpose. In this connection, however, it may be observed that the ear is a very poor substitute for the stethoscope when the latter is in a practised hand aided by an educated ear.

Of the fact that the heart in the lower animals is subject to most of the diseases which are well known in the human subject, the experience which has been gained by post-mortem examination has afforded abundant evi dence, and the veterinary pathologist has no difficulty whatever in recognizing the true characteristics of the various morbid conditions which are exhibited after death. His difficulty is confined entirely to the detection of each special form of disease in the living animal, and while he would not be content to accept Mayhew's imputation, that veterinary science cannot detect one state from another while the animal is alive, he would without hesitation admit the great difficulty of arriving at a satisfactory conclusion from symptoms which may be present at the time of his examination. Certainly it is the case that some of the most marked symptoms which Mayhew describes would not necessarily suggest to him the existence of any disease of the heart.

In connection with the subject of clinical symptoms it is fully recognized by the physician that the evidences of disease, or evidences which may be construed into signs of disease, of the heart, may be present in parts of the system remote from the organ itself. There is nothing at all remarkable in this proposition when it is remembered that the heart is the organ which distributes the blood over the whole of the body, and is therefore connected more or less directly with every other part of the system.

The natural result of this is, that diseases of remote structures or distant organs may so adversely influence the heart as to lead to indications which may easily, although incorrectly, be ascribed to derangement of the central organ itself; on the other hand, disease of the heart expressing itself by detectable alterations in its own sounds and movements is responsible for various forms of disturbance which occur in the digestive organs, liver, kidneys, or lungs, or some other parts. At the same time, it is thoroughly well recognized, as a fact about which there is no question, that grave structural and functional disturbance may affect the heart without leading to any manifestation at all which can be recognized as relating to that organ. In other words, an animal may die suddenly from heart-disease the existence of which had never been suspected during its life.

Among the symptoms which are frequently referred to disease of the heart are those which are described as subjective—that is to say, sensations which originate in the consciousness of the individual, such as pain, either continual or spasmodic, oppression in the chest, momentary stoppage or disturbance in the movements of the heart, dizziness, palpitations, and sinking. That these sensations, which are realized by the patient, are usually attended with extreme distress and apprehension will be readily understood, although it is a fact that all these clinical signs common in heart-disease may be experienced without any disease of the heart itself being present.

From the risk of error due to the existence of subjective symptoms, which would be usually classed under the head of extreme nervousness on the part of the subject, the veterinary surgeon is absolutely free. His patients either have no nervous apprehensions in regard to the state of their hearts or other organs, or, if they have, do not possess the means of expressing them in an intelligible manner.

Admitting, as must be the case, that disease of the heart of the horse is not so uncommon as it has been considered to be, the important question arises as to the best method of examination, for the purpose of detecting any obscure symptoms, which may be sufficient to direct the attention to the condition of the heart and the vessels immediately proceeding from it.

At the commencement it must be distinctly understood that while the veterinary surgeon is not subject to the risk of making an incorrect diagnosis in consequence of subjective symptoms or sensations which the horse cannot declare, he has to incur an equally prominent risk of arriving at a wrong conclusion in consequence of the derangement of the heart leading to disturbance of some other organs. The respiratory organs are, of course, most likely to be acted on. Any serious derangement of the central organ of circulation must necessarily interfere with the cir-

culation of blood through the lungs; anything which leads to excessive contraction of the right ventricle, by which the blood is forced into the lungs directly, or any interference with the action of the left side of the heart arising from deficient contractile power or mechanical obstruction in the passage of blood through the left auricle or ventricle, would naturally induce a state of engorgement of the vessels, or congestion of the lungs, which would be indicated by symptoms which the veterinarian recognizes without difficulty. The breathing would become rapid and oppressed, the surface of the body would very quickly become cold, and from other signs the examiner would very quickly diagnose congestion of the lungs. The affection may be sufficiently severe to justify him in calling it pulmonary apoplexy. Such a diagnosis would be in effect strictly correct, although it may leave out of consideration altogether the real cause, viz.: the blocking up of the vessels of the lungs with stagnant blood, not on account of any derangement of the respiratory organs themselves, but entirely owing to the circumstance that the heart is in such a condition that it is incapable of carrying on the pulmonary circulation.

It does not follow that the congestion of the lungs arising from defective action of the heart should take place suddenly to such an extent as would lead to any serious disturbance in the breathing, or justify the diagnosis of pulmonary apoplexy. Any mechanical difficulty affecting the circulation of blood in the lungs, whether arising from some impaired action of the heart or from any other interference, would lead to attacks of difficult breathing, cough, sometimes rupture of small vessels followed by bleeding from the nostrils, noises in respiration when it becomes at all hurried, sudden attacks of spasm, and in some cases a condition of the breathing which may lead to the impression that the horse is suffering from broken wind. Attacks of indigestion, and even gradually increasing emaciation, representing that state of the system which is expressed by the horseman's term "bad condition", are all indications which may be really consequent upon functional or structural derangement of the heart, although there may be no symptoms which specially direct attention to it.

As disease advances, more striking symptoms become evident. The wasting may be associated with dropsical effusions in the lower extremities and also along the inferior part of the abdomen, and there may be also more serious forms of dropsical effusion into the heart-sac (pericardium), the cavities of the chest, and abdomen. Chronic derangement in the central organ of circulation also leads to nervous derangement, in which the brain is commonly implicated. In the human subject, under these circumstances, the symptoms are easily recognized. The patient complains of frequent or even constant headache, with a feeling of fulness and heat

about the head, rushing noises, throbbings, flushing of the face, giddiness, sleepiness, irritability, impairment of the intellectual powers, or actual mental derangement, disturbance of vision, movement of bodies before the eyes, twitchings in the extremities, and attacks of faintness.

It will be perceived that the majority of these symptoms would not be recognized in the lower animals, and the few that would be apparent, such as unsteadiness of movement, attacks of vertigo (megrims), or twitching in the extremities, would possibly not be attributed to disease of the heart, and would probably not be in any way connected with disturbance of that organ. Under such conditions it is evident that a diagnosis must necessarily be of an uncertain character, unless by some accident suspicion of the true cause be aroused, and a careful examination of the heart lead to the detection of certain morbid conditions.

Physical Examination of the Heart and its larger vessels can only be undertaken by an expert who is familiar with the anatomy and physiology of the organs of the circulatory system, and on this part of the subject the reader is advised to consult the sections on the anatomy and physiology of the heart. Armed with the knowledge thus obtained, even the tyro will be able to realize the importance of constant experience in the use of the instruments which are employed for the purpose of the examination of the heart and vessels, even if he does not contemplate devoting himself sufficiently to the subject to obtain the necessary skill. In the first place, the examination which will be required will have regard to what can be ascertained by the use of the hand applied to the cardiac region, and also to certain of the most superficial arteries. The amount of force exercised by the heart in its contraction produces a distinct impression to the hand of the examiner when placed upon that part of the walls of the chest against which it strikes or beats, and the impulse communicated by the heart to the blood which passes through the arteries produces a beat as nearly as possible at the same time as the contraction of the heart. This is described as the pulse, and upon its character and frequency some opinion may be formed as to the general condition of the central circulatory organ, as previously described in the section relating to the symptoms of disease.

In the next place, percussion over the cardiac region, performed by a light but sharp stroke with the points of the fingers, will make the examiner acquainted with any alteration in sound as compared with that emitted from the chest of the perfectly healthy subject. For example, where dulness of sound is found to extend beyond the area of the healthy heart, enlargement or hypertrophy of the organ would be suspected.

Next to percussion, auscultation is employed by the use of the stetho-

scope in human practice, by the application of the ear to the part where the lower animals are concerned.

The object of this form of examination is to distinguish any abnormal sounds which may exist in connection with the beats of the heart. These sounds can only be distinguished by the expert who is familiar with the healthy sounds, which may be described as far as it is possible to describe them in words as follows:—First, there is a sound which is believed to be produced by contraction of the ventricles. This is called the *systolic* sound, and it is also distinguished as a long sound, the term being used, of course, comparatively. This systolic sound is followed by a short interval of silence, which is succeeded by the second, described as the *diastolic* sound, which occurs when the ventricles cease to contract, and the valves guarding the pulmonary vessels and the aorta close. The diastolic sound is followed by a rather longer silence than that which succeeds the first, and then the systolic or first sound recurs. The duration of the sounds and intervals is expressed by dividing the whole period occupied by the series into ten parts, and then subdividing as follows:—Systolic sound $\frac{4}{10}$, first interval $\frac{1}{10}$, diastolic sound $\frac{2}{10}$, and second interval $\frac{3}{10}$. The actual character of the sounds as they strike the ear has been expressed by Dr. C. J. B. Williams by the words "lub-dup". Very little difficulty would be experienced in rendering the ear accustomed to the normal sounds of the heart, but it must be clear that an acquaintance with the abnormal sounds and their meaning could only be acquired by long practice with the assistance of a competent instructor. The most that the tyro could hope to achieve in this direction without such assistance would be the recognition of a change from the normal sound of the heart or its large vessels, and he would arrive at the knowledge simply from the observation that the normal sound with which he had rendered himself familiar had undergone certain modifications.

The expert, in making an examination, not only realizes the fact that there is a change from the normal sounds to the abnormal, but he distinguishes also to the seat and cause of the abnormal murmurs; for example, variations as to the intensity of sounds, whether increased or diminished, alteration with regard to pitch and clearness of the systolic sounds, will inform him as to the condition of the valves and walls of the heart. A very clear, sharp, high-pitched, systolic sound will be more commonly heard in cases of anæmia, or extreme debility; again, alterations in the duration of the sound give important information as to the condition of the heart. In dilatation of the ventricles, with increase in the thickness of the walls, the systolic sounds will be prolonged, and the diastolic sound will probably be much shortened and very much obscured; whereas, in dilata-

tion of the cavity, without any alteration in the thickness of the walls, the diastolic sound is longer than normal, while the systolic is shortened.

The pathologist also obtains a great deal of information while examining his patient by comparing the sounds which are heard in different parts of the chest, especially over those parts which correspond to the lower part or apex and the upper part or base of the heart. If the sounds are weak at the apex and louder at the base, the evidence is accepted as serving to distinguish effusion into the heart-sac (pericardium) from dilatation of the cavities or fatty condition of the heart. Intense sound at the right apex over and above that at the left may indicate either displacement or enlargement of the right side of the heart; it also occurs when a portion of lung unduly distended with air (emphysematous) is interposed between the heart and the walls of the chest.

A murmur or, as it is commonly called, "bruit" is generally taken to indicate friction at some point over which the blood is passing, and in the majority of cases it is allowed that the murmur depends on some morbid condition of the valves which guard the orifices of the heart.

There are certain situations in which the murmurs relating to different parts of the heart are most readily heard. Thus murmurs connected with the mitral valves (fig. 191) are described as loudest just above the apex beat, while the murmurs which are connected with the valves of the aorta are most marked at the base of the heart. In the descriptions which are given in works on pathology a much more intricate and extended account of the different sounds in different positions is given, but sufficient has been written to indicate to the reader the very abstract character of the subject, and the enormous difficulties which attend a critical examination of the heart with a view of making a correct diagnosis of any existing disease. Indeed, with all the facilities which the physician possesses, including the use of the most elaborate and perfect instruments, the power to place his patient in any position which he thinks most convenient, and of regulating the character of the respirations with regard to their depth and frequency, or of arresting the action altogether for a short period, so as to obtain absolute silence in the respiratory organs of the chest, there is still a considerable difference of opinion existing among experts as to the cause and meaning of certain sounds which can be recognized.

Diseases of the heart and its connections are for convenience divided into those which affect the membranes enclosing and lining the organ, and those attacking the muscular structure of which it is chiefly composed. Thus we have acute or chronic inflammation of the membranous sac in the double layer of which the heart is completely invested, and similar affec-

tions involving the fine membrane which lines the cavities of the heart, and these two morbid states are designated by different terms according with the position occupied by the structures. Where inflammation affects the former it is spoken of as *pericarditis*, or inflammation of the investing membrane; while the term *endocarditis* is used to indicate inflammation of the membrane which lines the cavities of the heart and contributes to the formation of the different valves. Inflammation of the valvular structures is also distinguished by the term *valvulitis*. Inflammation, acute or chronic, of the muscular structure of the heart is described as *myocarditis*, which is commonly associated with inflammation of the membrane investing or lining the heart.

PERICARDITIS—INFLAMMATION OF THE HEART SAC

Inflammation of the pericardium may occur under a variety of circumstances, sometimes in connection with rheumatism, strangles, and influenza, or any low form of fever or specific blood disease. It may also arise from injury, such as a wound inflicted from without, or from the passage of some foreign body from the digestive organs, through the diaphragm into the pericardial sac. This cause is comparatively frequent in cattle, but is extremely rare in the horse. One case is recorded in which a sewing-needle had passed through the œsophagus into the pericardium, and subsequently reached the right auricle of the heart.

As in other cases of disease connected with the central circulatory organ, pericarditis, especially the chronic form, may exist for a considerable period without any symptoms being present which would lead to the suspicion of its existence. This is particularly the case in reference to what is called traumatic pericarditis in cattle. These animals, when at pasture, frequently swallow various extraneous substances which come in their way, and among foreign cattle kept by small owners, and fed very much about the dwelling-houses, it used to be extremely common to find in the rumen of the animals, which were sent to this country for slaughter, various domestic articles, such as brushes, tin or other toys, hair-pins, shawl-pins, skewers, knitting-needles, and even portions of wearing apparel.

In post-mortem examination it frequently happens that a needle, or piece of wire, or a skewer, is detected in the heart sac, and its path can be traced through the second stomach (*reticulum*), which lies close to the diaphragm, and from that organ into the pericardial sac, and sometimes into the muscular structure of the heart. In other cases, where the body which has inflicted the injury has been lost in the course of the examination, the path which it has taken can be distinctly followed from the

second stomach into the heart sac. This condition of things has not uncommonly been observed in animals in good condition sent to the slaughter-house without any suspicion arising that they were subjects of such severe injuries.

Symptoms.—The symptoms of pericarditis of the acute form are very often complicated with those of ordinary inflammation of the lungs and pleura (pleuro-pneumonia), and indeed, in fatal cases of the latter disease, it is quite usual to find indications of inflamed pericardium.

In such cases as the above there would, of course, be great difficulty in separating the symptoms belonging to each set of organs, but it is generally allowed that the character of the pulse, the irregularity of the heart's action, and the presence of a venous pulse in the jugular vein may be taken as indications that the heart sac is implicated in the inflammatory condition.

In pericarditis resulting from injury it is certainly the case that the disease may advance to a considerable extent before any symptoms of illness are apparent; in some cases there may be no particular signs of derangement until the foreign body, needle or skewer, reaches the heart. It has been noticed at the termination of these cases, when the fact of the existence of the disease has been made patent by a post-mortem examination, that the animals for some time before death have been subject to frequent attacks of indigestion, associated with elimination of gas into the rumen in the case of cattle, and into the single stomach of the horse. As a result of the disease, a quantity of fluid, clear or turbid, is usually found in its cavity, with adhesion of a portion of the membrane perhaps to the heart, and sometimes considerable thickening of the structures.

Pericarditis which is independent of the passage of any foreign body or other injury is distinguished as *idiopathic*, a form which seldom occurs unless in combination with pleuro-pneumonia, and, as previously stated, it is scarcely likely that it would be distinguished at once as a distinct disease in the presence of inflammation of the lungs and pleural membrane. In the event, however, of any suspicion being excited which would lead to an examination of the heart by the application of the ear to the left side, over the cardiac region, it would be discovered that the normal sounds of the heart are less distinct, and if fibrinous exudation has taken place between the two layers of the pericardium, friction sounds might be detected in the early stages of the disease.

Treatment of the idiopathic form of pericarditis may be attempted with some hope of success. It would include the administration of a saline aperient, and in some instances, when the symptoms are very marked, and the heart is affected with palpitations, digitalis is recommended. Fomentations, or the hot pack, or counter irritation to the region of the heart, may

also be employed. The body should be well clothed and the legs bandaged, while the strictest quietude should be insisted on.

ENDOCARDITIS—INFLAMMATION OF THE LINING MEMBRANE OF THE HEART

This disease is said to be more frequent in the horse than the one which has just been referred to. When it occurs in association with rheumatism, it is more likely to end fatally in a short time than ordinary inflammation of the pericardial membrane, in consequence of the liability of the valves to undergo thickening, and the blood to coagulate upon them and upon the surfaces of the heart's cavities.

Symptoms indicative of endocarditis of the ordinary kind have been differently described by different observers.

The physical signs of the disease are: excited action of the heart, and the presence of certain sounds which are described as endocardial murmurs. The friction or rubbing sound which is recognized in pericarditis will not usually be present.

It is somewhat remarkable that little or no pain is manifested during the progress of the malady. The pulse at the commencement is frequent and full in its beat, afterwards becoming feeble and irregular. Fever is sometimes very pronounced, and at others it tends to assume a low subdued form. The results to be apprehended are deposits within and upon the valves and round about some of the orifices, thus interfering with the passage of the blood, and leading to obstruction and the formation of large fibrinous clots. These are not unfrequently broken up into small fragments by the movements of the heart, some of which are carried along the course of the circulation, and may thus lead to fatal obstruction by blocking up vessels in important organs.

The malignant forms of the disease, associated with the formation of abscesses and ulcerations, have only now and again been recognized in the horse.

Treatment.—When the disease is complicated with an attack of rheumatism, salicylic acid and its salts must be resorted to and persevered with to check the progress of the disease. Perfect rest must be enforced and every form of excitement avoided. The bowels should be gently acted upon as required by the administration of small doses of sulphate of magnesia, and any manifestation of heart weakness must be met by the careful employment of digitalis and ammonia.

MYOCARDITIS, OR INFLAMMATION OF THE MUSCULAR STRUCTURE OF THE HEART

This disease occurs very rarely in the lower animals, and most probably when it does happen it is connected with other diseases which have been described, *i.e.* pericarditis and endocarditis, in both of which the inflammation may extend to the muscular structure.

Continental writers refer to myocarditis as an infectious disease associated with aphthous fever, septicæmia, tuberculosis, and contagious pneumonia of the horse.

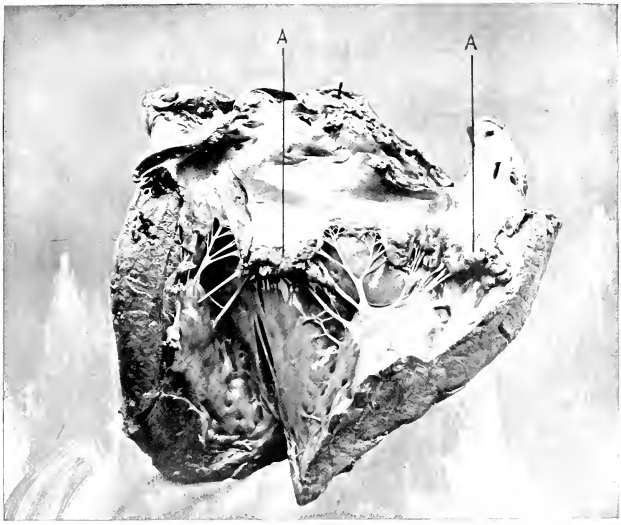
The alterations which are occasioned in the muscular structure will depend upon the activity of the inflammatory condition. Among them may be mentioned softening, and different degrees of degeneration, which weaken and impair the functions of the organ.

In its chronic form the disease tends to the development of hypertrophy or enlargement, hardening of the muscular structure, and different forms of fatty and fibroid degeneration, and in some instances small abscesses are formed in the muscular walls.

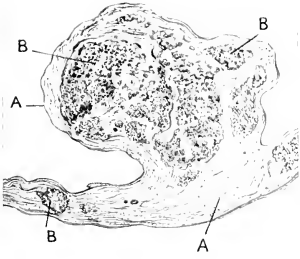
Symptoms of myocarditis are not of a sufficiently definite character to lead to a correct diagnosis. In the majority of cases the pulse is weak, sometimes hardly detectable, generally increased in frequency, and the respiration is rapid and carried on with difficulty. Sometimes, when caused to turn, the animal grunts, and deep pressure over the region of the heart causes pain. There is also weakness, incapacity for work, a fastidious appetite, and occasional attacks of vertigo, especially in the advanced forms of the disease. There is an absence of the morbid sounds which are observed in cases of pericarditis and endocarditis, and in valvular disease.

DISEASES OF THE VALVES OF THE HEART

Endocarditis in the chronic form may be expected to lead to a certain alteration in the valves which guard the openings leading to and from the different cavities of the heart. The alterations of structure may consist of thickening of the valves, adhesion of one to the other at their edges in particular, and to the walls of the cavities. In some cases they develop large excrescences, or, as they are sometimes called, cauliflower growths, which occupy a considerable space in the cavities of the auricles or ventricles. (See Coloured Plate.) Among the domestic animals the pig appears to be most subject to these growths, which have been constantly found in the post-mortem examinations of animals which have died or been slaughtered in consequence of swine fever.



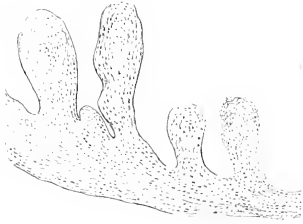
A, A. Valves of the Heart much thickened as the result of Valvular Disease



Calcareous degeneration of the mitral valve

A, A. Fibrous tissue

B, B, B. Calcareous degeneration



Fibrous vegetation of the mitral valve

VALVULAR DISEASE OF THE HEART (Endocarditis)

Many years ago Youatt referred to the common presence of these vegetations in the heart of the pig, and he noticed in particular that the animals in which the disease was detected in the slaughter-houses had given no evidence whatever of the existence of such tumours during life.

Valvular disease in the heart of the horse is, according to Professor Nocard, more common than it is suspected to be. He has given a table of the relative frequency of the different valvular affections in that animal. Of forty-two subjects it was found that thirty-eight had disease of the valves of the aorta. In the other four, disease both of the aortic and mitral valves was detected. In some cases one of the normal sounds is obliterated, or may be reduplicated, or it appears every other or every second beat.

The character of the morbid alteration varied considerably. In some cases the valves were merely thickened and hardened, in others they were contracted, sometimes they were indented or perforated, and in others they were covered with fibrinous deposits.

In the cases referred to, the diagnosis had been made during the life of the animal, and in almost all of them a blowing noise, which occurred during what would ordinarily be the interval between the normal sounds, was detected by auscultation. It is remarked by Dr. W. L. Zuill, in his translation of the work on pathology by Drs. Freidberger and Frohner, that the first symptoms of this chronic inflammation of the lining membrane of the heart is the marked weakness of the animals while at work. They will stop, refusing to advance, and do not respond to the voice or to the whip.

Treatment is not likely to be attended with any great advantage. The recommendation to avoid excitement and any active exertion is tantamount to proposing to keep the affected horse in the condition of useless idleness.

For the purpose of temporary alleviation of the most marked symptoms, the use of iodide of potassium with digitalis is recommended, but, excepting where some special value is placed on the patient, economy, and humanity too, would be best considered by having him destroyed.

HYPERTROPHY—ENLARGEMENT OF THE HEART

The different forms of disease and deformity affecting the valves, which have been adverted to in the preceding remarks, necessarily cause obstruction to the circulation, attended with regurgitation of the blood and increase of pressure in some of the cavities of the heart. Any obstruction arising out of disease of the valves is likely to occasion enlargement of the heart in one or another part of the organ according to the particular valves affected.

Obstructive disease of the aortic valves gives rise to thickening of the walls of the left ventricle, while the same condition of the pulmonary valves would similarly affect the right.

Enlargement of the heart may arise from increase in the development of the muscular structure (hypertrophy of the muscular walls), or from dilatation of the cavities from extra pressure from within. But it is pretty generally recognized that the same obstruction which gives rise to hypertrophy will also occasion dilatation of the cavities, hence it is found that both conditions usually exist to a greater or less extent at the same time.

The heart of the horse, which in a normal condition weighs about seven or eight pounds, may be increased in this disease to twelve or more pounds.

Hypertrophy and dilatation are much more common in the left ventricle than in the right, for the reason that the valves of the former are more liable to sprain and disease than those of the latter. It will be remembered that the left ventricle sends the blood over the entire body, while the function of the right is confined to distributing it over the lungs. The work entailed in the former act being so much greater than that of the latter, the chances of obstruction to the blood flow are correspondingly increased. Thus the aorta, the vessels of the kidneys or the liver, or those of one or more of the various organs of the body, may by disease become narrowed, and tend to obstruct the circulation, which in time the heart would attempt to overcome, and its increased effort would have the effect which follows all muscular work, of sooner or later causing thickening of its walls. If the obstruction continued, or for any reason became worse, dilatation of the heart would follow hypertrophy. In these cases the valves which guard the orifice are required to stretch in order to fill up the still larger opening, or they sprain and become diseased.

It does not necessarily follow that because the heart is enlarged its walls should be thickened. This will frequently depend upon the amount of dilatation which it has undergone. In some cases the walls are much thinner than normal owing to the hypertrophy not having kept pace with the dilatation.

Symptoms of Enlarged Heart.—It is certain that very considerable changes may take place in the muscular structure of the heart without any symptoms at all being apparent. When, however, the changes are such as to disturb materially the function of the organ, the disease is rendered apparent by very obvious signs, afforded in the first instance by a physical examination of the chest. If the enlargement be due to hypertrophy, the impact of the organ against the walls of the chest will not only be increased in intensity, but it will be felt over a much greater area than normal when

the open hand is placed over the region of the heart. Moreover, the area of the dull sound commonly invoked by percussion is extended in proportion as the heart is enlarged, and this is the case whether the enlargement arises from hypertrophy or from dilatation, or both combined. There is, besides, more or less palpitation, especially under circumstances of exertion and excitement.

The usual recommendations to avoid excitement and fatigue are given when the disease is diagnosed, but as a matter of course, unless it is in such a stage that the rest that would be necessary need only be temporary, the animal is rendered perfectly useless, and might as well be destroyed. In fact, this alternative appears to be the reasonable one in all cases in which the disease is indicated by marked symptoms. For example, when an animal affected with a large heart—whether it consists in simple hypertrophy or only dilatation, or of the two conditions together—suffers from increased respiration when at rest, and to a greater extent during exertion, with the addition of staggering, attacks of vertigo, trembling, sometimes convulsions, and frequently derangement of the digestive organs, leading to loss of condition, emaciation, and anæmia, it may be concluded that the chances of recovery are so remote that it is not worth while to attempt any treatment.

ATROPHY OF THE HEART

This condition, which refers to a diminution in the size of the organ owing to wasting of the muscular tissue and a general failure of its contractile power, is much less common than the enlarged state, hypertrophy and dilatation. The characteristic symptoms are those which would be expected from the anatomical changes. The circulation becomes extremely feeble, the pulse is small and weak, and general failure of the supply of blood to the whole of the system leads to passive congestions in different organs and rapid emaciation, which would terminate fatally if the end were not anticipated, as it usually would be, by slaughtering the animal.

FATTY DISEASE OF THE HEART

Two perfectly distinct conditions are included in the term fatty disease of the heart. One consists in mere infiltration of the fatty material among the muscular fibres of the heart, which may be observed in animals when overfed (fatty infiltration), and the other consists in the actual conversion of the muscular structure into fat (fatty degeneration). In the former, the cells in the connective tissue between the muscular fibres become filled with fat, and there is an excessive deposit of fatty material outside the

heart and round the base, and in the grooves in the walls of the organ, along which the blood-vessels pass. In connection with this deposit of fat the muscular structure becomes pale and flabby.

Symptoms.—Fatty infiltration is found to exist in the case of animals which spend an idle life or do very little work, and are supplied with an undue quantity of food. Such animals are usually referred to by stablemen as being in soft condition, and it is recognized in reference to them that they are incapable of active work, rapidly becoming exhausted and suffering from shortness of breath and palpitation of the heart on slight exertion. The circulation is necessarily weak and languid, the extremities are cold, and an examination of the heart would reveal the characteristic symptoms of feeble impulse and much-diminished intensity in the normal sounds; when the deposit of fat is excessive, it may happen that no sound can be detected at all. The condition is modified by the circumstances under which the fatty infiltration takes place. In horses which have been fed to be brought into what is known as dealer's condition, a process which has probably only occupied a few weeks, regular exercise and change in the character of the food will, in the majority of cases, restore the animal to a healthy condition. It is only after the excessive feeding, with insufficient exertion, have been continued for a long period that the diseased state is likely to become permanent, and even in such cases considerable improvement in the animal's condition may be effected by persistent employment of the ordinary measures, which would come under the head of physical training, including carefully-regulated exercise, the avoidance of food containing a large proportion of fattening material, and the careful adjustment of the food given to the quantity of work performed.

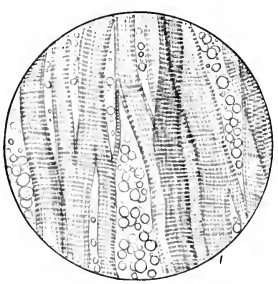


Fig. 194.—Fatty Infiltration of Muscle

[1] Muscle Fibres (healthy). [2] Fat Corpuscles.

Fatty Degeneration.—This condition of the heart may be associated with long-continued fatty infiltration, or it may follow an attack of inflammation (Myocarditis), or arise in the course of some wasting disease, or as a result of one or another of the acute specific fevers. It is mostly found to exist in old animals, and the progress of the malady is considerably favoured by a sedentary life; in fact it may occur in an exaggerated form in animals which are not plethoric, although it appears that want

of sufficient exercise conduces very much to the progress of the malady. The anatomical changes resulting from the disease are extremely marked, and very easily recognized by the use of the microscope. The muscular walls are, as in the case of fatty infiltration, commonly paler in colour than the normal structure, and often present a faded yellow or pale-brown tint; the muscle is easily torn or broken down, and has been compared in texture to wet brown paper. Under the microscope the muscular fibres, instead of being well defined with perfectly distinct transverse markings, present a granular appearance owing to the presence of minute granules of fat in their structure, and in some advanced cases every trace of the fibrillated appearance of the normal fibre has become obscured, and only a mass of fat granules can be recognized.

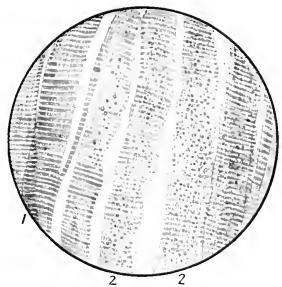


Fig. 195.—Fatty Degeneration of Muscle

[1] Muscle Fibre (healthy). [2] Muscle Fibres infiltrated with fatty granules.

Symptoms.—It is well known to pathologists that fatty degeneration may advance to a considerable extent without any symptoms becoming apparent. An animal may die suddenly from the disease the existence of which has not been suspected during its life. This will be quite intelligible to the veterinarian, as the occasional unpleasant sensations which are recognized by the human patient over the cardiac regions would find no expression in the horse. Occasional attacks of what in the human subject is described as "angina pectoris" may occur in the horse, but would either be, as is usually the case, unnoticed, or, if observed, would be referred to an attack of colic or probably a spasm of the diaphragm.

Williams, in his book on *The Practice of Veterinary Medicine*, records one case which came under his notice, which he considered to be an instance of angina pectoris in a well-defined form. The animal was an aged cart-horse, which for twelve months had done very little work, owing to the fact that when he was excited by work or exertion, he suffered extreme pain in the left fore-limb, the muscles of which, with the muscles of the chest (pectorals), became violently convulsed. The paroxysm seldom occurred when the animal was at rest, but there was a continual twitching of the muscles, and the animal appeared to dread being approached. On examination by auscultation, a loud cooing or blowing sound was heard

over the region of the heart, and there was a strong impulse indicative of hypertrophy. There was also observable a distinct regurgitation of the blood in the jugular vein or jugular pulse. No opportunity in this case was afforded for a post-mortem examination.

In some cases of this disease the pulse is remarkably slow, the beats of the heart are generally feeble, irregular, and intermittent, and while exertion increases the frequency of the pulse, it also renders it more irregular, any severe effort soon brings about exhaustion, sighing, and giddiness.

Examination of the heart during life reveals certain signs which are said to be characteristic: the impulse is feeble, but is at the same time well defined; the sounds are weak, in the case of the first sound almost inaudible, and in very advanced cases the sounds may be altogether absent; and it is noticed in regard to the feeble pulse that there is sometimes only one pulsation to two beats of the heart.

RUPTURE OF THE HEART

The various alterations in the structure of the heart, arising out of acute myocarditis and the different kinds of degeneration, naturally lead to a weakness and a diminution in the resisting power of the muscular walls, which favours the occurrence of rupture. The determining causes are: violent exertion, falls, excessive excitement, tympanitis, an overloaded condition of the stomach or intestines, &c. Any one of these causes, by obstructing the passage of blood in the larger vessels, increases the pressure on the walls of the heart beyond its power of resistance. It is stated by Zuill that the tear is usually located in the walls of one of the auricles. In our experience it has most frequently occurred in the left ventricle. The occurrence is usually almost immediately fatal; it is said that in falling at the moment of the rupture the horse sometimes utters a piercing cry. When the rupture is slight the ordinary symptoms of internal hemorrhage are exhibited. The animal staggers, and, if not supported, falls, the visible mucous membrane of the nostril, mouth, and eye become white and bloodless; there is difficulty of breathing, loss of consciousness, and convulsions, and death occurs at varying periods, from a few minutes to several hours. Obviously treatment even in prolonged cases is not likely to be of any use, although it is sometimes effectual in cases of internal hemorrhage from rupture of the vessels of the liver. Here large doses of opium, with gallic or tannic acid, has sometimes arrested the flow of blood, and the animal has partially recovered, but a rent in the walls of the heart is necessarily irremediable.

DISEASES OF THE ARTERIES AND VEINS

Certain structural changes occur in both arteries and veins owing to inflammatory attacks and certain forms of degeneration and injuries occasioned by the presence of parasites, &c.

ARTERITIS

Arteritis, or inflammation of the walls of an artery, is by no means a rare disease in the horse. It is usually the result of some irritant acting upon the vessel from within.

In man the causative agent is commonly found to be some granulation or vegetation occurring in the structure of the aortic valves.

These, when sufficiently large, repeatedly strike the wall of the vessel during the movement of the valves, and excite inflammation in the part struck; or it may result from a portion of blood clot liberated from the interior of a large vessel being carried away and arrested in a smaller one, producing a plugging of the vessel, or embolism.

In the horse the disease is most commonly seen in the anterior mesenteric artery and in that part of the aorta in immediate proximity to it. It is the result of irritation excited in the vessel by the presence of worms. The parasites *Strongylus armatus* frequently take up their abode here, and by their presence induce inflammation in the vessel wall.

The vessel, which is at first thickened, becomes soft and very much like a piece of wet wash-leather. Its elasticity is impaired or altogether lost, and in consequence it gradually yields to the pressure of the blood stream, and ultimately becomes dilated and forms an aneurism. On the internal surface there is frequently to be found a quantity of coagulated fibrine, in which the parasites are embedded.

Symptoms.—The chief symptoms of this disease are wasting, and diarrhœa, and periodical subacute abdominal pain. The animal is dull and listless, tucked up in the belly, feeds indifferently, and sometimes refuses food altogether. If a sharp look-out be kept, small red worms will be found in the excrement.

In these cases the partial plugging of the mesenteric artery diminishes the quantity of blood flowing towards the intestine. The function of that organ is therefore imperfectly performed, resulting in periodical attacks of diarrhœa, colic, and a general unthriftiness of the affected animal.

The patient sometimes brightens up and appears to have recovered, when recrudescence of the disease occurs, and he goes back in condition, and may succumb to the disease.

Treatment.—In all cases of this kind the treatment will succeed in proportion to the injury done to the vessel, and the amount of obstruction to the blood-flow resulting from the degree of dilatation, and the extent to which the vessel has been narrowed by the coagulation of fibrine within it. Very many cases are hopeless, and if they do not die it would be real economy to have them destroyed at once. Some recover, only, however, to be a future trouble to whoever may possess them.

These facts should be present to the mind of all persons who are called upon to treat cases of this kind.

As we have already indicated, the treatment of this disease is very uncertain. The affected animal should be placed in a well-littered box, and everything should be done to keep up the strength of the body. Food easy of digestion is of the first importance here. Malt meal and linseed, crushed oats and bran, with a very small quantity of sweet chaff, all well scalded, will be found for the most part suitable.

It is no use trying to destroy the parasites; they are beyond our reach, and cannot be influenced by medicines; but they may sooner or later leave the vessel of their own accord and pass into the intestine.

When pain appears it must be combated and controlled by the administration of repeated small doses of opium. A little bicarbonate of potash with chloride of sodium may be administered with the food, and repeated small doses of turpentine and aromatic spirits of ammonia should be given in combination with tincture of cinchona as a stimulant and tonic.

ATHEROMA (ENDARTERITIS DEFORMANS)

This is a disease most commonly seen in the arch of the aorta, or at a little distance posterior to that point.

The early stages of the disease are marked by the appearance of small greyish-white spots and patches which are noticed scattered over the interior of the vessel, slightly raised above the surface, and somewhat irregular in size and in form.

The inner surface of the aorta is perfectly smooth, but somewhat irregular over the seat of the patches. The endothelium lining the vessel remains for the present quite intact, but the inflammatory new growth situated beneath it raises the endothelium in the direction of the interior of the vessel.

In the second stage the cell proliferation, or growth, to which the patches are due, undergoes a process of fatty change or degeneration, and becomes soft, yellow, and cheese-like, or assumes what is known as an *atheromatous* condition (ἀθήρη = meal).

The degenerative process may extend to the cells lining the vessel, when they break down, and expose the underlying pasty matter.

Should this occur, the blood in its course backwards washes up the degenerated inflammatory product and carries it away, leaving the middle and external coat exposed.

In the third stage of the disease the pasty mass, instead of being thus removed, becomes more or less calcified, in which case small bone-like spicules are seen ramifying through the structure of the vessel wall, in some instances completely surrounding it and giving it the appearance of a bony tube (see Aneurism, fig. 196).

The effect of this disease on the wall of the vessel is seriously to spoil its elastic reaction, and so interfere with the circulation.

When the inflammatory products have undergone the softening process, and become exposed to the blood current, the vessel yields to the pressure from within, causing it to dilate still further, and in consequence an aneurism is formed, or the blood may insinuate itself between the coats of the vessel and cause them to separate, when a dissecting aneurism is the result.

When the vessel becomes thin, as is sometimes the case in this form of the disease, its walls may rupture, and death take place more or less suddenly, or the fibrine of the blood coagulated on the diseased surface may fill up the vessel and form a thrombus.

If in the second stage of the disease the pasty mass or some adhering clot of fibrine becomes exposed to the current of the blood, and carried away, some portion of it may be arrested in a distant small vessel, establishing the condition of embolism.

If this should occur in the lungs, or the brain, or the kidneys, organs specially predisposed to embolism, further, and perhaps fatal, mischief may be the result.

THROMBOSIS

Both arteries and veins are liable to become more or less completely obstructed during life by the coagulation of blood within them. When this condition occurs it is described as "thrombosis", and the obstructing clot is spoken of as a "thrombus". In the present day, thrombosis in the horse is only of seldom occurrence. Formerly, when blood-letting was resorted to in every conceivable ailment, it was a common affection of the jugular vein, and frequently gave rise to permanent obstruction and obliteration of the vessel.

Causes.—The causes of thrombosis are chiefly injuries in one form or another, such as wounds, severe contusion, and stretching; indeed anything

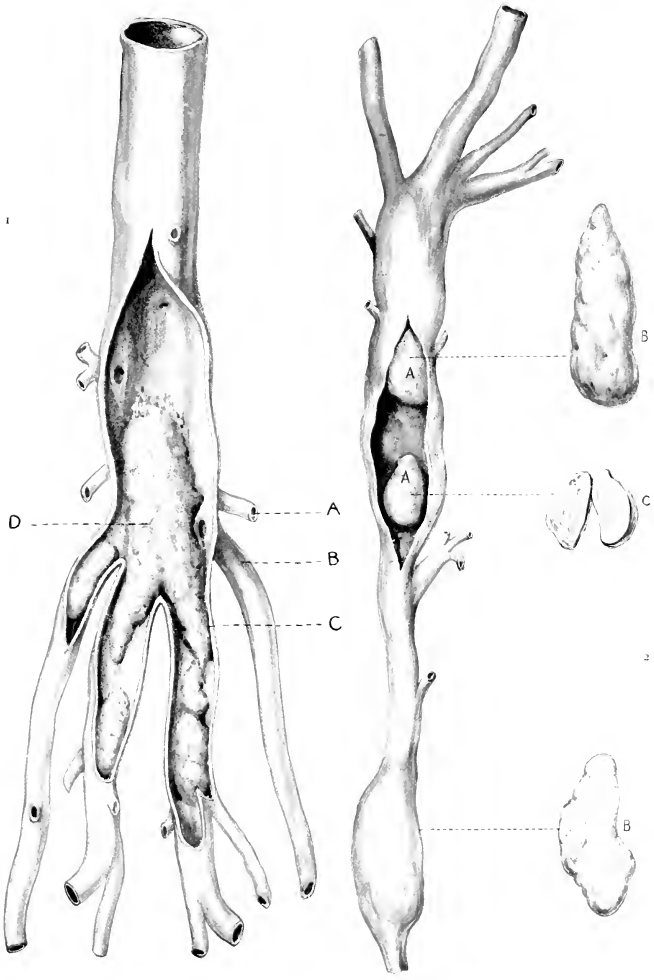
which will excite inflammation in the vessel wall or diminish its vitality may determine the coagulation of blood within it. It is also a consequence of degenerative changes in the structure of the vessel, and of arrest of the circulation from aneurism (fig. 196), or any other cause which induces the blood to stagnate.

ILIAC THROMBOSIS

The most notable example of thrombosis in the horse is that which is seen now and again in the iliac arteries—the vessels into which the abdominal aorta breaks up beneath the lumbar spine, and whose branches are distributed to the hind-quarters and extremities.

Causes.—For the most part thrombosis of the iliac vessels is the result of sprain inflicted upon them by some violent backward stretching of the hind-limbs, such as would result when a horse falls short in jumping and slips down the bank of a drain, or when his legs fly back from under him, or "spread-eagle", while drawing a heavy load over a slippery surface, or out of deep heavy ground. The writer has also known it to be occasioned in the course of the struggles of a horse while cast in a railway box, and in another instance the disease followed upon a hunter being "hung up" across a gate. In all these positions there would be sudden and severe stretching of the vessels and injury to their coats.

Symptoms.—The symptoms of iliac thrombosis will vary with the stage of the disease, but, when well established, they are very diagnostic. At first the patient displays slight stiffness of one or both hind-limbs, more especially on rising from the recumbent posture, or when first led out of the stable. This, however, will pass away with a little exercise, to reappear again from time to time in a more and more marked form. It may be accompanied by slight swelling of the limbs. As the arteries become more and more blocked, and the circulation obstructed, the legs are found to be cold, and the large veins are distended. This distension of the veins results from the absence of force to move on the blood within them, consequent upon the blocking up of the arteries, and is most strikingly seen during rest. When the animal is made to move, the blood disappears from the veins, and returns but slowly. The horse's movements are observed to be somewhat unsteady behind, especially during work. In the more advanced stages of the disease exertion brings on a rolling gait behind, and, if continued, results in paralysis of the posterior part of the body At this time the animal breaks out into a profuse perspiration, the breathing is hurried, the muscles quiver, and the pulse is much accelerated. In some cases the affected animal strikes the belly, looks round to the flank, and shows signs of acute pain, as if the subject of colic.



THROMBOSIS

Fig. 1. A. Circumflex artery of ilium. B. External iliac artery. C. Internal iliac artery with Thrombus in situ. D. Thrombus.

Fig. 2. Jugular Vein. A, A. Phleboliths in situ. B, B. Phleboliths removed. C. Phlebolith in section.

After a short period of rest the symptoms subside, and the horse resumes his normal condition, and will most likely continue in apparent good health until the exertion is again repeated. Although the symptoms described are very indicative of iliac thrombosis, the diagnosis may be rendered still more complete by a careful manipulation of the affected vessels. In this connection it will be remembered that the iliac arteries are to be found striking off right and left beneath the lumbar spine, and quite within reach of the hand when pushed well forward into the rectum. In carrying out this examination the hand and arm must be well anointed with oil or vaseline, and after entering the bowel the arm is turned so that the palm is presented upward; the fingers are then directed to that part of the spine where the loin joins on to the quarters, immediately beneath which the great iliac vessels—two on either side—will be felt branching off right and left from the posterior aorta.

When healthy, they are found to pulsate forcibly with each beat of the heart, and to be distinctly compressible, though always tense. When, however, they are filled with coagulated blood and rendered solid, as in this disease, the pulsation is no longer felt, and the vessels become hard and unyielding. If they are not completely blocked a slight pulsation may be felt, as a thin stream of blood passes over the clot, but the affected vessels in any case will have lost their pliancy, and will offer very decided resistance to deep pressure.

Treatment in these cases is of no avail. The fibrinous matter plastered over the inner surface of the vessel in successive layers, or free within it and occluding the passage of the blood, cannot be removed, and the animal should therefore be destroyed.

THROMBOSIS OF THE JUGULAR VEIN (PHLEBITIS)

As already noticed, thrombosis of the jugular vein was a disease of common occurrence in the days of indiscriminate blood-letting and unclean surgical practice as pursued before the advent of antiseptic surgery when phlebitis frequently followed the operation. In more recent years, since the lancet and the fleam have been laid aside, it has become a rare and exceptional ailment.

As in arteries, so in veins, thrombosis is the result of degeneration or injury inflicted on the wall of the vessel. It also results when the vessels become varicose or abnormally dilated. In the particular instance under consideration it follows upon the operation of bleeding, or the accidental opening of the jugular vein. But the immediate cause is not perhaps the injury alone, but the introduction into the wound at the time, or

subsequent to its occurrence, of some septic or decomposing matter. A dirty fleam or lancet, a dirty pin, or dirty tow employed to bring the edges of the divided vessel together, are the most likely media by which to infect the wound. Inflammation of the vessel having been thus excited, the blood circulating within it is induced to coagulate, and to be deposited on the inflamed surface layer after layer until the passage becomes completely obstructed and the flow of blood along the neck on the affected side is arrested in its course towards the heart.

Symptoms.—The lips of the wounded vessel are more or less tumefied and separated from each other, and the parts around are swollen and painful to the touch. The plugging of the vessel invariably proceeds in an upward direction, where it may be felt for some distance as a hard, cord-like thickening in the channel of the neck. Subsequent changes in the condition of the vessel and its contents will depend upon circumstances. In some instances the wound heals, the plug becomes organized, still retaining its position in the vein, with which it unites to form a solid cord. Here the general health of the patient is but little impaired; since, however, the jugular vein is no longer able to convey the blood back from that side of the head to the heart, the vessels of the face will be inordinately distended, the brain will be somewhat surcharged with blood and liable to slight functional disturbances, especially when the head is held in a depending position. This danger will be materially modified after a time, when compensating enlargement of the jugular vein of the opposite side and its tributaries takes place, and their carrying capacity becomes thereby increased.

It must be understood that with one jugular vein spoilt the conveyance of blood from the head to the heart will have to be done for the most part by the other, which, in course of a little time, will widen out and accommodate itself to the task imposed upon it.

Animals having suffered from this disease should not be turned to grass or allowed to eat from the ground. The downward position of the head under the altered conditions of the circulation tends to an accumulation of venous blood in the vessels of the head, resulting in swelling of the lips and tissues of the face, dizziness, and vertigo.

Instead of being organized, the plug in the vein may soften and break up into a pus-like matter, resulting in the formation of one or more abscesses in the upward course of the swelling. These may break, empty themselves, and heal, perhaps to form again and produce deep sinuous wounds in the track of the vessel. The most serious consequences resulting from jugular thrombosis occur when matter from the softened and disintegrated clot finds its way into the circulation. Thereby the blood

becomes poisoned. The septic particles are distributed over the body, and, settling down in some of the more important organs, produce destructive abscesses or a condition known as "pyæmia".

Treatment.—Any appearance of thickening in the course of the jugular vein, such as we have described, should be met by prompt measures of treatment. A dose of physic will first be called for, and at the same time all hard corn is to be knocked off and replaced by sloppy mashes of bran and scalded chaff. The wound should be repeatedly irrigated by carbolic solution and covered with antiseptic gauze. Hot fomentations applied over the injured vein will aid in reducing inflammatory action and checking the progress of the disease when permissible. Should abscesses form, they will require to be opened, and to be well syringed out with antiseptic dressing from time to time and packed with antiseptic wool.

Some practitioners recommend a blister to the swollen vein, and place complete reliance on this form of treatment. There can be no doubt that in some subacute and slowly progressive cases such a course might prove beneficial, but in the more active and severe attacks the course recommended above would be more appropriate.

ANEURISM

Under certain conditions arteries are liable to undergo dilatation in certain parts, so that the cavity of the vessel is more or less enlarged. Such a state is known as an aneurism. This form of disease is more especially seen in foals and young horses, as a result of the presence of parasites in the large vessels which supply blood to the bowels. It may also be brought about by sprain or any injury which may induce inflammation and consequent softening of the vessel. Aneurism is sometimes seen in the aorta, as it courses beneath the spine, and more rarely in some other of the smaller vessels. In some instances the presence of the tumour does not seem to give rise to any disturbance in the circulation which can be recognized during life, and is therefore only discovered after death. Where, however, the dilatation is considerable, it may very seriously incommode the circulation, and by causing obstruction lead on to hypertrophy, with dilatation of the walls of the heart and embarrassment in the breathing.

In the horse, aneurism most frequently occurs in the anterior mesenteric artery as the result of injury done to the walls of the vessel by parasites (*Strongylus armatus*). How these creatures gain access to the vessel is not exactly decided, but most likely by boring their way through the tissues

of the bone. When in the vessel they excite irritation in the walls, resulting in inflammatory softening, and the pressure of the blood from within acting upon a yielding surface results in dilatation or aneurism. At the same time the existing endarteritis provokes fibrinous deposit on

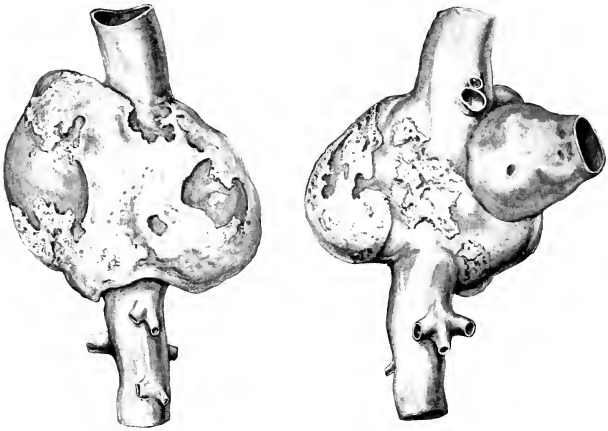


Fig. 196.—Aneurism of the Aorta

the inner surface of the vessel, tending to its more or less complete closure. As a result of this, the intestines fail to receive their proper amount of blood, on account of which diarrhœa is induced and prostration follows.

ANÆMIA

Anæmia is a term employed to denote a condition of the blood in which there is a deficiency of iron, an element essential to the formation of red blood cells, deficiency in which results in poverty, weakness, and general malaise.

The causes of anæmia are numerous. Chief among them may be mentioned insufficient or improper food, close confinement, impure air, specific disease, chronic discharges, hemorrhage, the action of lead and other deleterious agents in the food or water, and parasitism. In the case of young horses at grass, the first and last named are perhaps the more frequent, while stabled animals suffer greater risks from bad hygienic

conditions. The anæmic state may be very gradually acquired where bad hygienic conditions exist, or it may follow more quickly upon diarrhœa, influenza in any of its many forms, glanders, and parturient troubles in the mare, and the multiplication of parasites within the body.

Symptoms.—There is pallor of the membranes lining the eyelids and the nasal cavities; the tongue has a limp or soft feeling not imparted to the hand in a healthy animal, and conveys an impression of coldness to the touch; emaciation and debility coexist with a harsh, dry skin, and dropsical swellings appear from time to time, especially in colts at the end of the winter, when the fare has been poor and the season cold and wet. Low, marshy, water-logged land is especially conducive to anæmia in young animals. Persistent or pernicious anæmia results in great weakness, loss of spirits evinced by drooping head and listlessness, nervous irritability and palpitation of the heart when suddenly disturbed, a want of co-ordination of the voluntary muscles, and, in mares or fillies, suppression or absence of the œstrual periods are sometimes induced, and a peculiar murmur or ripple is heard near the region of the heart.

The pulse is irregular, feeble, and intermittent, and sudden attacks of palpitation of the heart come on now and again, when its contractions may be heard at a considerable distance.

As the heart grows weak, and nervous prostration increases, respiration becomes shallow, digestion is impaired, and the desire for exercise diminishes. Abdominal pains, of the nature of mild attacks of colic, and a distended or tympanitic abdomen are not unfrequently noted.

Treatment.—Since the causes are so many and varied, they should be carefully investigated before a remedy is prescribed. It would be useless, for instance, to rely solely upon a blood restorative if the maintenance of a host of parasites within were the cause. In colts at grass the little worm *Strongylus tetracanthus* infests the bowels in some seasons to such an extent as to destroy the life of its victims without for a time producing other marked symptoms than those of anæmia. Anthelmintics combined with tonic remedies will here be indicated. (See Parasites.)

The anæmia which follows upon specific diseases, such as influenza, strangles, &c., will be combated by mineral and vegetable tonics and a diet at once nutritive and easy of digestion. In the case of colts which have suffered from the inclemency of the winter, and pasture of inferior quality, a careful process of building up of the system is advised, and it has to be borne in mind that animals in this state must not be too hastily supplied with a full ration of nutritious diet, because the power of digestion and assimilation has suffered in common with all the other functions of the body. At first milk and then gruels should be given in conjunction with

a moderate allowance of more solid food. Crushed linseed and malt flour are valuable adjuncts to the food allowance at this period, and should be given in small but frequent portions.

A good deal may be done by supplying medicines from both the vegetable and mineral kingdoms, bitter tonics, as quinine, gentian, calumba, and chamomile, the sulphates of iron and copper. As iron is the element most wanting in the blood of the anæmic, and necessary to rebuild the red corpuscles, it enjoys a reputation as being almost a specific for this form of the malady. In the case of horses it has to be given with caution, as, with the extremely debilitated, it is too irritating and astringent to be borne in full doses. For the very weak and emaciated the saccharated carbonate or the ammonio-citrate is preferable to the more commonly employed sulphate.

PLETHORA

This abnormal condition is now seldom described in works on veterinary medicine, and some authorities have even denied its existence.

The better management of horses has greatly reduced the number of cases met with, but the condition can scarcely be forgotten by anyone who has witnessed it. It is an almost precisely opposite state of the blood to that described under the heading of anæmia. The subject is usually fat, or else has been so suddenly placed upon a too liberal diet that the circulatory fluid has become rapidly loaded with red corpuscles, and what has probably more to do with the symptoms presently to be described is the accumulation of effete material in the blood which the emunctories fail to eliminate. Urea and other deleterious products of combustion circulate in the blood stream, producing effects varying with the quantity, and the idiosyncrasy of the individual.

Causes.—Idleness conjoined with over-feeding upon highly nitrogenous food. Close stabling and want of exercise. Inactivity of the liver, kidneys, and skin; but these latter are usually secondary and dependent on bad hygienic conditions.

Symptoms.—Trembling and blowing are sometimes present, but closer inspection shows, in addition, engorgement of the vessels of the conjunctiva and more or less cerebral disturbance, denoted by excitement, followed sooner or later by a dull, heavy expression. The pulse is full and hard at one time and quick and irritable at others. The extremities are variable as to temperature, but the ears are commonly hot and the appetite fastidious or altogether in abeyance.

Treatment.—This is one of the few disorders for which the veterinarian may, with advantage, resort to venesection. It is attended with

immediate relief of the more pressing symptoms. Where the disorder is not of an urgent character, bleeding will be dispensed with, and reliance placed upon an aloetic ball, a spare diet, and, as soon as permissible, exercise followed by regular work. There can be little doubt that this malady is often mistaken for pulmonary congestion. A horse that has once suffered from plethora should receive special care as to diet when his services are not in demand, and laxative foods, as bran, more frequently given; for in keeping the bowels active safety is found.

SEPTICÆMIA

The term septicæmia is employed to indicate certain forms of blood-poisoning which result from the entrance into the circulation of disease-producing bacteria or their products. All the various contagious disorders, such as glanders, strangles, &c., are so many special forms of septicæmia, in addition to which there are others commonly originating in wounds.

When septicæmia results from the entrance of bacteria into the blood, it is termed *septic infection*.

If the blood of such an animal be inoculated into a healthy subject the disease is communicated by the bacteria which it contains.

In this form of the affection, therefore, bacteria are the direct inducing factor.

But septicæmia may also result from chemical poisons formed by certain kinds of bacteria, as when organisms of putrefaction set up decomposition of the tissues in wounds, and the poisonous products resulting therefrom are absorbed into the blood. This form of septicæmia is known as *septic intoxication*, and is not transmissible by inoculating the blood into healthy stock.

Pyæmia is also a form of septicæmia, but distinguished from all the rest by the development of abscesses in various parts of the body. The organisms by which this disease is excited have the peculiar property of inducing the formation of matter (pus).

Symptoms.—Blood-poisoning in any form is a dangerous and commonly fatal affection. It is ushered in by a fit of shivering, which may be repeated again and again. There is a marked rise of temperature, attended with great prostration, a quick feeble pulse, and increased respiration. Muscular pain and weakness is shown by the weight of the body being constantly shifted from one limb to another. The mucous membranes of the eyes and nose are of a yellowish-red hue, and in severe cases blood spots or blotches appear upon them. The mouth is clammy, the tongue furred, and food is altogether refused.

In pyæmia there is, in addition to these symptoms, the formation of abscesses in various parts of the body, sometimes on the surface, at others in one or more of the internal organs. The lungs, brain, liver, and kidneys, in some instances the joints of the extremities, are the parts most frequently invaded. The duration of pyæmia is more protracted than in the other forms of septicæmia, and although very fatal, it is not so generally destructive.

Treatment.—In dealing with this form of disease it is of the first importance that the strength of the patient should, as far as possible, be upheld. If the appetite fails, as is usually the case, eggs and milk should be freely given three or four times in the course of the day.

The flagging heart must be stimulated by the administration of brandy, whisky, or gin, with which quinine should be given three or four times, or more, in the twenty-four hours.

Where wounds exist they should receive prompt attention. The hair should be removed from about them, and the surrounding skin and the wounded surface must be thoroughly washed with well-boiled water and then freely irrigated with some antiseptic solution, after which it should be enclosed in antiseptic wool, and be carefully dressed as occasion requires.

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7. THE ORGANS OF RESPIRATION AND THE RESPIRATORY PROCESS

The act of breathing is so intimately associated with the continuance of life that we commonly speak of the "first" and "last" breath as terms synonymous with the beginning and end of existence. Yet that which is referred to in this sense is really only the outward movement or visible mechanism of respiration, that is to say, the means by which the introduction and expulsion of air is effected, and takes no heed of the changes that take place in the air, in the blood, and in the tissues of the animal. These, however, represent the true end and aim of the respiratory process, for experiment has shown that the persistent manifestation of life is invariably associated with the absorption of oxygen and the elimination of carbon dioxide, that the exchange of these gases is properly termed the process of respiration, and that it is accomplished in all parts of the system. Every tissue, but, above all, the muscular, develops carbon-dioxide in its substance, which, by means of the capillary circulation, is brought into relation with the blood which has taken up oxygen

at the lungs. In obedience to physical laws, an exchange of gases is immediately effected; the blood rendering up the oxygen it contains to the tissues, which in turn give up the carbon dioxide they have formed in their substance to the blood. This process constitutes "internal or tissue respiration". The blood, now deprived of part of its oxygen and charged with carbon dioxide, passes by the veins to the right heart, and from thence to the lungs, where it surrenders its carbon dioxide to the air, as well as some watery vapour, and in return takes up oxygen from it. This constitutes "external respiration". The great muscular vigour and

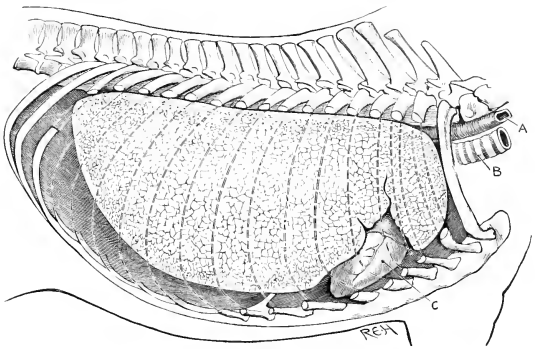

Fig. 197.—The Lungs in their Natural Position

A, Œsophagus. B, Trachea. C, The Heart.

the activity of the horse are necessarily associated with a voluminous and highly-developed respiratory apparatus, by means of which the required large exchange of gases can be effected. Accordingly the thorax, or chest, which is of great size, is chiefly occupied with the lungs, which are composed of a spongy tissue presenting an enormous surface of contact for the air, a surface that even in man has been estimated at 81 square metres, or more than 54 times the superficial area of the skin, and that must be many times greater in the horse.

The air enters the lungs through the nostrils, which are the true commencement of the respiratory tube, and then traverses successively the larynx, trachea, large and small bronchial tubes, reaching ultimately the air-cells of the lungs. The nasal cavities present a large and very irregular surface, covered with a mucous membrane that is constantly moist and

is highly vascular. The upper part is supplied with the olfactory nerve, which is the special nerve of smell, whilst the lower part is supplied with branches of the fifth pair of nerves, which confer upon it a high degree of common sensation. Several objects are gained by the inhaled air passing over this surface. The impressions received by the sense of smell, and conducted to the brain, serve to place the animal on guard against enemies, whilst they inform it of the proximity of food, water, or other objects of desire. The acuteness of their perception in these respects is well known.

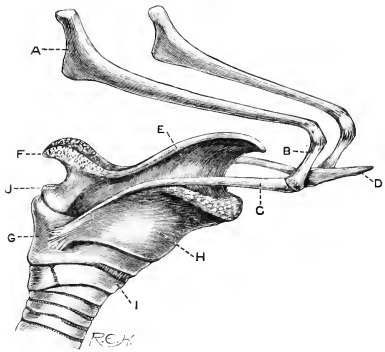

Fig. 198.—The Larynx

A, Long Cornu of Os Hyoides. B, Short Cornu. C, Thyroid or Heel-like Process. D, Spur Process. E, Epiglottis. F, Glottis. G, Cricoid Cartilage. H, Thyroid Cartilage. I, First Ring of Trachea. J, Arytenoid Cartilage.

But it does more. It warms and moistens the air as it is inspired, and thus prevents cold, raw, and dry air from acting directly on the delicate tissue of the lungs. Having reached the back of the nose, the current of air crosses the pharynx and enters the larynx, shown in side view in fig. 198, and looked at from above in fig. 199. The larynx is a cartilaginous chest or box containing the organ of voice. Continuing its course the inspired air travels through the trachea or wind-pipe and the bronchial tubes, the divisions of which penetrate, and indeed form, a large proportion of the substance of the lungs. In the act of expiration the air passes through the several passages just named in the opposite direction.

The Lungs.—When full of air the lungs are two voluminous soft elastic organs of pink colour, which occupy with the heart nearly the whole of the thoracic cavity. In old animals they are more or less mottled with black. The right lung is rather larger than the left, and each is covered with a thin sheet of a serous membrane, named the *pleura*, which also lines the inner surface of the ribs and walls of the thorax. The opposed surfaces of this membrane are polished, and at all times lubricated with a watery secretion, so that in the acts of respiration the gliding

movements that occur between the lungs and chest wall are allowed to take place with the least possible friction.

The Larynx (fig. 198) is a chamber of irregular form externally, which is connected with the hyoid bone or bone of the tongue (A, B, C) above and in front by means of a small ligament, and is continuous with the trachea behind. The chief of the cartilages composing it is named the thyroid (H), from its resemblance to a shield. It consists of two wing-like portions, joined at an angle in front, but open behind. To its fore part is attached the epiglottis (E) (fig. 199), a tongue-shaped body which covers the entrance to the glottis when food is swallowed, thus preventing the passage of any portion of it into the larynx or trachea.

Behind the thyroid cartilage is the cricoid cartilage (G), which resembles a signet-ring with the wider part above (fig. 198). Articulating with this wider part behind are the two arytænoid cartilages (fig. 198). These are of pyramidal form, and the vocal cords or organs of voice extend from their inferior angle to the internal surface of the thyroid cartilage.

The larynx possesses many muscles which effect the movements of the several cartilages on one another during respiration, and by tightening the vocal cords determine the pitch of the notes which the animal is capable of emitting.

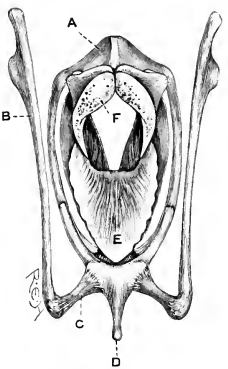

Fig. 199.—The Larynx, seen from above

A, Cricoid Cartilage. B, Long Cornu of Os Hyoides. C, Short Cornu. D, Spur Process. E, Epiglottis. F, Glottis.

The Trachea is a long wide tube occupying the middle line of the neck, and separated from the spine by the œsophagus or gullet. It extends from the cricoid cartilage of the larynx to about the fourth dorsal vertebra. It is about 3 feet in length and 2 inches in width. It is composed of about fifty C-shaped pieces of cartilage, each of which is converted into a ring by a strong muscular and elastic band stretching across from one side of the cartilage to the other. Elastic and fibrous membranes also extend between the edges of the rings, so that a continuous tube is formed, and this is lined by a mucous membrane the innermost layer of which is composed of epithelial cells having upon them fine hair-like processes termed cilia.

Towards the lower part of the trachea the rings are replaced by irregularly shaped fragments of cartilage (fig. 200). The cartilaginous frame-

work effectually prevents the trachea from being closed by any moderate pressure that may be exerted upon it, and air is consequently always capable of reaching the lungs without interference. The entrance of food or of any foreign body into the trachea is jealously guarded against, and it is only when these parts are, so to speak, taken by surprise that such an accident can happen. In the first place the mucous membrane of the whole of this region is rendered extremely sensitive to touch by the distribution of the superior laryngeal nerve, which is a branch of the vagus. Then in the act of swallowing, the whole larynx and trachea are drawn close up behind the tongue by muscular action, whilst at the same time the epiglottis is drawn downward to meet them, and in this way the opening into the larynx is closed against the entrance of food. At the same moment the vocal cords are brought together and the space between them reduced to a mere chink; whilst lastly, if, in spite of these precautionary arrangements, a fragment of food should by chance enter the larynx or trachea, it is immediately expelled by a violent expiratory effort or cough.

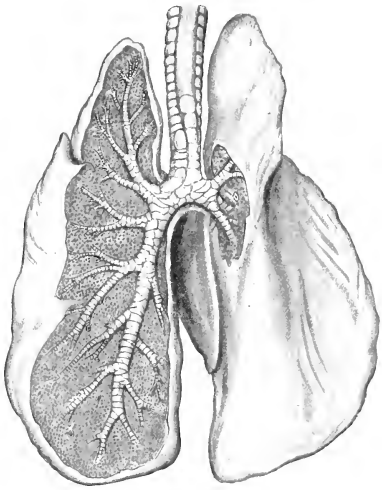

Fig. 200.—The Lungs and Bronchi

The Bronchi.—The trachea on reaching the chest divides into the two bronchi, one going to each lung. As seen in fig. 200, they then divide and subdivide again and again till the tubes are scarcely larger than a hair, when they are termed *bronchioles*. These, after a short course, suddenly change their character, becoming dilated into sack-like ends, and presenting depressions, cups, or pits on their walls as shown in fig. 201.

The Air-cells.—These cups constitute the air-cells, *alveoli*, or *vesicles*

of the lungs. They are surrounded by a close net-work of minute blood-vessels (capillaries), and it is here that the aeration of the blood takes place. The air vesicles have a diameter of from $\frac{1}{100}$ to $\frac{1}{200}$ inch, and their number has been estimated to be 750,000,000 in man, whilst it must be at least three times as many in the horse. Their walls are composed chiefly of elastic fibres loosely interwoven, which confer upon the lung tissue the great elasticity it possesses, and the epithelium lining them is no longer columnar and ciliated, as in the bronchioles, but flat and thin, thereby permitting the free passage of gases through them.

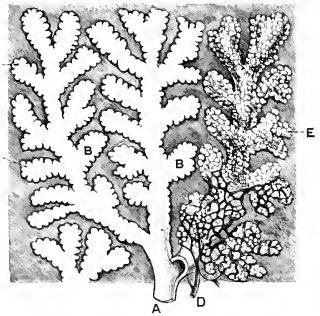

Fig. 201.—Sack-like Ends of a Bronchiole

A, Bronchial Tube divided. B, Infundibulum or Terminal Sac. C, Air-cells. D, Artery breaking up into Capillaries around and between E, Air-cells.

The distribution of blood through the lungs is effected by the right heart and pulmonary artery, which contain dark venous blood. As the blood traverses the pulmonary capillaries around the air-cells it gives off carbon dioxide to, and takes up oxygen from, the air in the alveoli, and is then returned to the left heart as aerated blood by the pulmonary veins.

EFFECTS OF RESPIRATION

Composition of the Air.—The composition of the atmosphere has been proved, by the analyses of many chemists, to be nearly uniform in all parts of the world, excepting in regard to the quantity of watery vapour it contains, which is, of course, far less in cold dry regions than in those which are moist and warm. Pure, dry air is a mixture of 21 parts of oxygen, 79 parts of nitrogen, and a small proportion of carbon dioxide, amounting to 1 part in every 2500 parts of this mixture. In addition to the constituents above mentioned, smoke, containing compounds of sulphur as indicated by the tarnishing of silver, and ammonia, with accidental impurities derived from factories, are found near towns; and in the country at certain seasons of the year, and in certain localities, the pollen of plants and micro-organisms also impair its purity.

Air is 773 times lighter than an equal volume of water, and 14·47 times heavier than the same volume of hydrogen. For each degree centigrade of increased temperature it expands $\frac{1}{273}$ of its volume. The pressure of the atmosphere on each square yard of surface is about 20,000 lbs., and as the horse presents between 5 and 6 square yards of surface, it supports a pressure of 100,000 lbs., or 50 tons.

The air is rarely or never saturated with aqueous vapour, but the quantity rises with the temperature, and is greater therefore in hot climates than in cold, and in summer than in winter. It is greater also on plains than in mountainous regions, by day than by night, and where there is much vegetation than in arid districts. In moist tropical regions it may rise to 3 volumes in 100 of air, whilst in middle Europe it does not usually exceed 1·3 per cent, and may perhaps in this country be regarded as constituting between 1 and 2 per cent by volume.

Air after Respiration.—When air that has been once inspired is examined, it is found to have undergone considerable alteration. The proportion of nitrogen, indeed, is not materially altered—it still remains at about 79 in 100 parts,—but about 5 parts of oxygen have been abstracted, leaving the percentage of oxygen at about 16 per cent, while the quantity of carbon dioxide is increased from 1 part in 2500 to 112·5 parts in 2500, or to 4·5 per cent. The air is, in addition, rendered warmer, providing, of course, that when it was inspired it was not higher in temperature than that of the body. When this occurs, as it sometimes does in hot climates, the air inspired may actually be cooled by passing through the lungs. As a rule, the temperature of the expired air is raised to nearly 98°. Moreover, it is saturated with watery vapour which has evaporated from the moist mucous tracts of the nose, trachea, and alveoli of the lungs. It is also freed from all particles of dust and from all living or dead germs, which adhere to the moist surface of the respiratory tract, to be tossed outwards by the wave-like movements of the cilia of the ciliated cells lining the air-passages, and ultimately to be coughed up. Finally, some volatile gases or oils are added to it, as is proved by the peculiar odour of the breath characteristic of each animal, and especially observable after the use of certain articles of diet, such as garlic.

Putting the changes in the air in a tabular form, they may be thus represented:—

	Before inspiration.	After expiration.
Oxygen	21	16
Nitrogen	79	79
Carbon dioxide	0·04	4·5
Aqueous vapour	1 or more per cent	Saturated
Temperature	Variable	About 98°
	More or less germ-laden	Germ-free

It has been found that in the case of man, and probably therefore also in the horse, climate materially affects the absorption of oxygen. Thus, under ordinary conditions of respiratory activity in the hot climate of Madras, a man absorbs in one month 177 lbs. of oxygen, in the drier air of London or Brussels, 192 lbs., in the still drier atmosphere of St. Petersburg or Barnaul in Tomsk, 199 lbs., and in the latter place in winter, when the quantity of moisture in the air is at a minimum, as much as 218 lbs. These differences in some measure account for the languor experienced in hot climates, and for the briskness and great heat-producing power exhibited by the body in cold climates.

Air-changes in the Blood.—We may now enquire into the nature of the changes that take place in the blood from the time that it leaves the lungs in an aerated state, or in the condition of arterial blood, till it is returned to the heart in a venous condition after having traversed the various organs of the body. The results that have been obtained by those chemists who are the best qualified to deal with this difficult subject show that from 100 volumes of blood about 60 volumes of gas can be abstracted. The gases consist of carbon dioxide, oxygen, and a little nitrogen, the proportion differing considerably according to whether arterial or venous blood is examined. In both kinds of blood the carbon dioxide is in great excess. Thus in 100 volumes of *arterial* blood there are: oxygen 20, nitrogen 1 to 2, carbon dioxide 40 volumes. In 100 volumes of *venous* blood there are: oxygen 8 to 10, nitrogen 1 to 2, and carbon dioxide 46 volumes. The nitrogen may be dismissed from consideration at once, for it is known that it presents no special affinity for any of the constituents of the blood, that it is absorbed as water would absorb it, and that its volume consequently remains unchanged. It is different with the other two gases. The oxygen introduced into the lungs by the process of inspiration rapidly diffuses through the delicate walls of the air-cells and the blood-vessels around them, and at once enters into a feeble chemical combination with the hæmoglobin contained in the red blood corpuscles. By these it is distributed through the system, and in less than ten seconds reaches the capillary vessels, where the blood is brought into close relation but not in actual contact with the tissues. These have a stronger affinity for oxygen than the hæmoglobin of the blood; it therefore leaves the red corpuscles, and, passing through the thin walls of the blood and lymph vessels, finally attacks or is seized upon by the tissues, muscle or nerve or gland, as the case may be.

The quantity of carbon dioxide that is generated in the tissues, to be taken up by the plasma of the blood and to be discharged from the body at the lungs, is dependent upon many circumstances. To liberate the force

by which such an animal as the horse is able to accomplish its wonderful feats of locomotion, often under the disadvantage of having to drag a weighty load or to carry a heavy rider, something must be oxidized. At first sight it might reasonably be supposed that this something is the substance of the muscle itself, and this was long supposed to be the true explanation; but if this were the case, then nitrogen, which is an essential constituent of muscle proteid, ought to appear in the excreta after exertion in augmented quantity, either free or combined, as one of the products of the disintegration of that tissue. Careful chemical research, however, made both upon man and animals shows that exercise, even when violent and prolonged, does not materially increase the discharge of urea from the kidney, which is the chief channel by which nitrogen leaves the body. Hence the conclusion has been arrived at, that just as locomotion is effected in a steam-engine, with little wear-and-tear of the machine itself, the force being derived from the latent energy stored up in the fuel, so in the case of muscle the tissue itself is only the machine which utilizes the force set free by the combustion of some organic substance within it in which carbon is predominant. This substance, there is reason to believe, is glycogen, which is present in muscle at rest, but disappears after exercise, a substance that is in constant course of formation by the liver, and is stored up in the cells of that organ until it is again used up either by long fasting or after prolonged muscular exertion, and which, lastly, is a compound containing much carbon, whilst the oxygen and hydrogen in its composition are in the proportions to form water. During exercise more blood traverses the muscles, and therefore more oxygen is brought to them, the glycogen they contain is oxidized, carbon dioxide is formed, and water set free. The carbon dioxide is carried away by the blood, and is discharged partly by the lungs and partly by the skin; the water passes off by the kidneys. But other circumstances besides exercise affect the production of carbon dioxide. The quantity thrown off by the body is always increased after food. It is increased when the temperature of the surrounding medium is lowered, for since the temperature of the body is nearly 100° F., the oxidation of oil, of glycogen, and of proteids is necessary in order that it should be maintained. When, therefore, the external temperature falls, more of these substances must be ingested and oxidized to develop the required heat. The culmination of this is seen in the Esquimaux, who keep up their temperature during the severity of an Arctic winter by consuming large quantities of oily substances, the oxidation of which produces more heat in proportion to lbs. in weight than any other kinds of food.

In warm climates the amount of heat required to maintain that of the body is comparatively small; hence the propriety of reducing the quantity

of food supplied under these circumstances, and using the carbohydrates rather than the hydrocarbons.

Young animals eliminate more carbon dioxide than old ones in proportion to their weight, their tissues being more watery, disintegrating more rapidly, and being more amenable to oxidation. Females, on the other hand, making, as a rule, little muscular effort, give off less than males of the same age and weight.

The proportion of carbon dioxide that is eliminated, as compared with the quantity absorbed, is termed the respiratory quotient, and in the horse is $\frac{CO_2}{O} = 0{\cdot}9$, whilst in carnivora the proportion is $\frac{CO_2}{O} = 0{\cdot}77$.

The amount of water that is expelled from the lungs during respiration is considerable. The average quantity of water contained in air at mean temperature and pressure is about 1 to 1·5 per cent, but the air which is expired is raised to a temperature only a degree or two below 100° F., and it is saturated, containing therefore about 7 per cent of water vapour. It has been estimated that in man about 600 litres of water vapour, weighing 720 grammes, are given off daily, and the quantity given off by a horse may be taken at at least five times that amount.

THE MECHANISM OF RESPIRATION

The mechanism by which the respiratory acts are accomplished consists of the partly fixed and partly movable bony and cartilaginous framework of the chest and of the muscles, which form a large part of the walls of that cavity. The lungs themselves are passive agents, and only contribute to the movement of expiration by their elasticity. They accurately fill and fit the thoracic cavity, except in so far as room is afforded for the heart and great vessels. The principle on which tranquil respiration is accomplished is that the cavity of the chest becomes enlarged by muscular effort. As the diaphragm descends, and as the ribs are raised, air rushes in to equalize the pressure, and inspiration is effected. Then the muscular effort ceases, the diaphragm becomes more arched, the abdominal parietes, chest, and lungs retract by virtue of their elasticity, and expiration results.

The thorax, or chest, is a conical cavity, narrow and compressed from side to side in front, and expanded behind. It is formed of the strong and unyielding back-bone above, and the sternum, or breast-bone, below. Between these two parts extend the ribs, which number eighteen on each side, the first eight, or true ribs, being attached by their heads or upper ends to the spine, and by their lower ends, with the intervention of a piece

of cartilage, to the sternum or breast-bone. The remaining ten, false or asternal ribs, whilst attached above like the true ribs to the vertebræ, end below in cartilages which are only indirectly connected with the sternum.

The first and last ribs are the shortest, the ninth is the longest. They form a series of highly elastic arches, the sharpness of the curvature being greatest in the first and diminishing to the last. The articulations formed by the heads of the ribs with the vertebræ permit a slight degree of motion upon them. In complete expiration the ribs of the opposite sides of the thorax fall towards one another, and at the same time approximate to those of their own side by their edges, thus diminishing the capacity of the chest; whilst in full inspiration the ribs are raised, form wider curves, separate from those of the opposite side and from each other, and thrust the sternum forwards, in this way effecting enlargement of the chest both from side to side and from before backwards. The movements of the ribs are effected by muscles placed between them, named the *intercostals*. These consist of two layers of short muscular fibres which extend between the edges of adjoining ribs, the *external* running downwards and backwards, the *internal* running downwards and forwards, the former serving to raise the ribs, and thus to effect inspiration, which is aided by those fibres of the internal intercostals which extend between the cartilaginous portion of the ribs.

The front aperture of the thorax is occupied by the trachea, œsophagus, large vessels, and nerves, together with firm connective tissue. The posterior opening of the thorax is very wide, and is closed by the great muscular arch of the diaphragm or midriff. This important muscle divides the thorax from the abdomen. Its posterior concave surface is covered with the peritoneum or lining membrane of the belly, and is in contact with the liver, stomach, and organs of the abdomen; the anterior convex surface is covered with the pleura or lining membrane of the chest, and is in contact with the lungs.

The diaphragm is the most powerful muscle of inspiration, for in the act of contraction the arch it naturally forms falls back and tends to become a plane surface, and thus the cavity of the chest is enlarged from before backwards at the expense of the abdomen. In forced respiration the chest is acted on by many muscles which are attached to its outer surface, and which tend to raise the ribs and effect inspiration. On the other hand, the muscles of the abdominal wall tend to pull down the ribs, compress the abdominal organs, and force forward the diaphragm; they consequently cause expiration.

The enlargement of the chest during tranquil respiration is smaller

than might be expected, for if a tape be passed round the animal, just behind the shoulder, it will be found to enlarge only about $\frac{1}{8}$ inch, at the twelfth intercostal space about 1 inch, and at the last intercostal space about $\frac{1}{2}$ inch. It is estimated that the diaphragm moves backward towards the belly about 5 inches, lengthening the chest to that extent. The quantity of air inspired and expired at each respiration varies within wide limits. In tranquil respiration it may amount on the average to about 2 quarts with each respiration, or about 5 gallons per minute, when the number of respirations is ten, but after violent exercise the number of respirations may increase to one hundred or more per minute, with a corresponding increase in the volume of air breathed, amounting in one case to 97 gallons.

In the horse the act of inspiration is much more prolonged than that of expiration, the proportion being sometimes as much as two to one, and there appears to be a very short interval between the end of the one act and the beginning of the other.

The air that is used in respiration has been divided into four portions. First, there is that portion taken in during quiet breathing (tidal air), which may be estimated at from 200 to 300 cubic inches. But it is manifest that during exertion the animal can take in an additional amount over and above what it inspires in ordinary breathing. This is termed *complemental air*. Under these circumstances it also gives out with each expiration much more air than when an expiration has been made during rest; that extra quantity is named *supplemental air*. And these three portions—tidal, complemental, and supplemental air—are spoken of collectively as the "vital capacity". In young and strong animals, with free movement of the chest walls, the vital capacity is large; in old and weakly animals, when the cartilages of the ribs are ossified, and the lungs and thorax are less elastic, it is small. Finally, there is a portion of air termed the "residual air", which cannot be dislodged by the deepest expiration, but which is still subservient to the respiratory process in the air-cells of the lungs.

If in a healthy living animal the walls of the chest be cut through, as, for example, by a sabre cut, or be perforated, as by a stake or by a rifle bullet, so that the cavity of the chest is opened, or even if this be done in a dead animal, the lung immediately collapses and retracts from the wall of the chest, and the hissing of air entering through the wound can be distinctly heard. If one side of the lung only be punctured, respiration, though greatly impeded, is yet capable of being performed, but if both cavities are opened suffocation quickly ensues, for with each expansion of the chest the outside air enters the pleural cavity more easily through

the wound than through the trachea, in consequence of which the lungs become compressed and cease to perform their office.

The Nerves and Nerve-Centres of Respiration.—The nerve-centres which are implicated in quiet respiration are situated in that part of the brain termed the medulla oblongata, at the point where the vagi nerves take their origin. The destruction of this very small spot causes immediate death by arrest of the respiratory acts. It was accordingly named the "nœud vital", or vital spot, by Flourens. Nerve fibres run to and from this point. Amongst those which convey nervous impulses to it are the fibres of the vagus nerve which pass up to it. Those which conduct impulses away from it are fibres which pass down the spinal cord for some distance, and then emerge at the lower part of the neck and along the thorax to form the phrenic and intercostal nerves distributed to the diaphragm and the intercostal muscles.

When at rest, the horse breathes ten or twelve times per minute, and there is a general relation between the number of respirations and the number of the beats of the heart, the proportion being about 1:4 or 1:5, but the frequency with which the acts of respiration are performed is subject to great variation. At rest, or during sleep, the number is about ten or twelve in the minute, but after vigorous exercise, such as galloping for ten minutes, it may rise to fifty, sixty, or more in the same time, gradually subsiding as the animal becomes quiescent. In two horses, after a run of about 7 miles, the pulse was observed to rise from 40 to 132, and the respirations from 12 to 102, in the minute. After being at rest for three-quarters of an hour the pulse had fallen to 66 and to 54, whilst the respirations in each animal were 60 per minute (Arloing). The depth of the respirations greatly augments with increased frequency, so that a much larger volume of air enters, and is expelled from, the lungs at each inspiration and expiration. This constitutes forced respiration.

ASPHYXIA

This term, which, etymologically speaking, signifies pulselessness, has been erroneously applied to that condition in which there is great deficiency of oxygen, and, as a rule, increase of carbon dioxide in the blood. The amount of oxygen entering the lungs may be reduced rapidly by strangulation, or by closure of the mouth and nostrils, as in smothering, or by sudden closure of the glottis, as by choking, or by exposure to irrespirable gases, such as carbon dioxide and chlorine, or to such a gas as carbon monoxide, which, though respirable, replaces oxygen in the blood corpuscles, or by plunging the animal into another medium,

as into water or mercury, which is drowning, or by the simple withdrawal of oxygen from the air; or it may be induced more slowly by closing the air-tubes with the products of secretion, as in diphtheria or croup and laryngitis, or by paralysing the muscles of respiration, as by the action of curara, or by opening both pleural sacs simultaneously, thus preventing the lungs from following the expansion of the chest walls, or, lastly, by loss of blood. It is usually divided into three stages, the first of which, in rapidly-induced asphyxia, lasts about a minute, and is characterized by violent inspiratory efforts. Then the abdominal muscles contract powerfully, and strong expiratory efforts occur, which are succeeded by irregular spasms of the limbs, chiefly affecting the flexor muscles. The blood pressure rises to a great height, owing to the stimulation of the smaller vessels by the non-arterialized blood. In the second stage, which also lasts about a minute, the convulsive movements cease, the expiratory movements are hardly perceptible, the pupil dilates, and touching the eyeball excites no reflex movement of the lids. The blood-pressure gradually falls, and the muscles generally are relaxed. In the third stage, which lasts two or three minutes, the inspiratory efforts become more feeble, and only take place at long intervals spasmodically, the extensor muscles are convulsed, the head is thrown back, and death closes the scene.

VENTILATION

It may be taken for granted that air which has been once breathed is unfit for further respiration. Such air, we have seen, contains about $4\frac{1}{2}$ per cent of carbon dioxide, and experiment has shown that a far smaller proportion is poisonous, and it is generally admitted that a disagreeable or stuffy sensation is perceived by man when the air in a room contains about 1 per cent of carbon dioxide in 1000 of pure air. It is probable, however, that the feeling of closeness is not altogether due to the carbon-dioxide, but is in part owing to the exhalation from the skin and to the volatile products resulting from chemical changes in the body that are discharged from the lungs. M. Boussingault has estimated that a horse of average size eliminates 4800 litres, or between 8000 and 9000 pints, of carbon dioxide per diem, from which it is clear that a very large quantity of pure air must be supplied to prevent the proportion of the CO_2 from rising above 1 per cent. The object of good ventilation is to effect this renewal of the air without creating a draught, or, in cold periods of the year, causing a sudden inrush of air at a low temperature. In the case of the human subject it is held that to preserve the air in a fit state of purity, with ordinary or natural ventilation, at least 2000 cubic feet

of space should be allowed for each individual, and a much larger space, as might be expected, is required for the horse; but as a set-off to this it may be remarked that it has been found that the horse can bear without injury a larger percentage of CO_2 than man, and secondly, the construction and arrangements of stables are more favourable to natural ventilation than are the majority of human habitations. So if the space occupied by stables be somewhat smaller than those built for man, the renewal of the air is more effectually accomplished.

The term "natural ventilation" has been suggested by Pettenkofer, who has shown that, besides the interchange of air and gases that takes place through open windows and doors, or through the cracks and interspaces of boards and ill-fitting frames of windows and doors when these are closed, the walls of most dwelling-houses, when composed of brick or sandstone and mortar, allow air to pass through them with much greater facility than is usually believed. Thus it is found by experiment that the natural pores of such walls allow of the passage of 2000 cubic feet of air through—

42	square	feet	of a free wall	of sandstone.
30	,,	,,	,,	quarried limestone.
25	,,	,,	,,	brick.
19	,,	,,	,,	tufaceous limestone.
14	,,	,,	,,	mud.

Two circumstances are of great importance in regard to the activity of natural ventilation—the relative temperature of the air within and without, and the presence of moisture in the walls. Moisture, by filling up the pores, greatly obstructs, if it does not altogether prevent, the passage of air through walls. It is present in large quantities in new buildings, in which, therefore, no natural ventilation takes place, and which are proverbially unhealthy.

Pettenkofer found that in a room 14 feet square and 14 feet high, with a difference of temperature of 34° F. (66° F. inside, and 32° F. outside), the contents changed once in an hour; with a good fire in the stove it increased 25 per cent, and even when all apparent apertures and crevices were closed it only diminished 28 per cent. A stable built of mud is capable of permitting the entrance of a considerable volume of fresh air by natural ventilation, and can thus afford shelter to more animals than one built of sandstone. The activity with which the exchange of air is secured by natural and wholesome ventilation in a stable does not depend upon its cubic capacity, but upon the extent and nature of its ventilating walls and appliances, and hence a small stable built of porous material may secure better ventilation than a large one, partly because for each

animal there is more ventilating surface with equal cubic space, and partly because the air permeates the walls more readily.

DISEASES OF THE RESPIRATORY ORGANS

CATARRH OR COLD

Definition.—The term catarrh is generally used to describe an inflammatory condition of the lining membrane of the upper portion of the air-passages, commonly spoken of as "a cold", the special feature of which is a discharge of varied character from the nostrils, and sometimes the eyes also.

Causes.—The popular term—cold, or a cold—correctly points to the origin of many cases of this disorder, but it should be understood that there are other causes of catarrh with which cold has no concern. For the most part it results from lengthened exposure to inclement weather under conditions of exhaustion and inadequate food, sudden change from an overheated and usually badly ventilated stable to the outer cold, and it is the general experience among horsemen that the opposite conditions to the latter frequently cause it. It would seem paradoxical that an animal should take cold on coming from a cold atmosphere to a warm one, and from nakedness to clothing and comforts. The explanation is probably to be found in the unwholesome and irritating nature of the stable atmosphere upon the sensitive membranes of the air-passages. A horse requires a very large amount of air space, and the inadequate amount usually allowed is only tolerated when he has become acclimatized to close quarters. The advantages of pure air as a curative agent, when catarrh is established, are so well recognized among horse-dealers that some adopt the heroic though imprudent course of turning them out in a field. When the skin of a weak perspiring horse is suddenly exposed to a cold wind, the surface circulation receives a check of which the cold is a reaction or local manifestation. The animal's condition at the time of exposure would appear to have much to do with his susceptibility in this respect; indifferent health and fatigue are unquestionably predisposing conditions. The horse in hard condition, sweating but not exhausted, will bear a cold shower-bath without taking cold, but his vital powers are sufficiently great to produce a healthy reaction.

Infection.—An infectious form of catarrh is now generally recognized, and as such the disease periodically visits most large establishments where a great number of horses are stabled. Young horses, fresh from the country and drafted into town studs, seldom escape an attack, but their susceptibility to further infection would appear to be materially reduced as a consequence.

Symptoms.—Slight shivering fits usually usher in the attack, which more often than not pass unobserved. Then follow yawning and listlessness, hanging the head and general dulness, staring of the coat, which feels harsh to the touch. The temperature of the extremities is variable, while that of the central parts of the body is increased, the thermometer introduced into the rectum indicating a rise more or less marked according to the severity of the attack. In some individuals sneezing is a prominent symptom, but it cannot be described as general. The nasal membrane is dry and the colour somewhat heightened, this symptom being followed by a watery discharge, in which the eyes also may participate. The watery fluid changes in a few days to a thick mucus or muco-purulent discharge. The appetite is usually impaired during the febrile stage, while a painful cough is a frequent concomitant later on.

Treatment.—With good nursing, pure air, and suitable food a common cold is not difficult to manage. Danger in these cases mostly results from neglect in giving timely attention to the case, or in putting the patient to work too soon. A fortnight should be allowed in which the disease may run its course. There is no remedy that will cut it short, but such agents as are selected will be given with a view to ameliorate the symptoms and enable nature to throw it off as soon as possible. In the early stage salycine in one or other of its combinations appears to hasten the discharge and lower temperature, spirit of nitrous æther being given with the same object. Acetate of ammonia has also been long in favour. When the discharge has become thick, and provided there is no cough, the sulphates of iron and copper are calculated to impart tone and arrest a tendency to a chronic discharge. If cough accompanies the disease, a smart liniment may be applied over the region of the throat, and a mixture of paregoric and glycerine, with some of the sweet spirit of nitre, may be found beneficial. Where a difficulty in swallowing points to an inflamed condition of the pharynx a gargle of chlorate, or nitrate, of potash is recommended, there being no objection to its being swallowed. Where debility and languor continue after the acute symptoms have abated, carbonate of ammonia with bitter vegetable tonics are prescribed. The nostrils should be sponged with warm water to which a little permanganate of potash has been added, and the edges anointed with vaseline to facilitate the discharge of nasal mucus. The food should be moistened and easy of mastication: linseed-tea, mashes, and carrots, with chaff and hay steamed, and the drinking-water should have the chill taken off in winter. If grass is available it may be given freely, nor need the attendant be alarmed if it imparts some of its colour to the discharge escaping from the nostrils.

CHRONIC NASAL CATARRH—NASAL GLEET

Definition.—A lasting discharge from the nasal chambers, of varying quantity and character. When accompanied by an offensive odour it is known as ozœna.

Causes.—Chronic discharges from the nostrils are usually the sequel of catarrh, in some cases resulting from cold, in others from influenza or strangles, from which the patient has been brought low in condition and made but a tardy recovery.

The membranes high up in the facial cavities have entered upon a chronic low form of inflammatory action, by which an unhealthy secretion is formed, which, when retained, appears to aggravate the condition. If the disease is confined to the nasal chambers only, the prospect of restoration to a healthy state is much greater than when the sinuses of the face which communicate with them are the seat of unhealthy action. When this is the case, the matter may accumulate and become so thick as to make removal only possible by a surgical operation. In coal-mines the habitual inhalation of dust and unwholesome air is said to cause nasal gleet, as does also the foul conditions found on shipboard. Quite a large proportion of sea-born horses suffer from catarrh, and a greater proportion of cases of chronic nasal discharge are found among these horses than result from catarrh contracted in the usual way. In addition to the causes stated, nasal gleet not unfrequently arises out of a diseased condition of the fangs of the teeth and of the bones of the facial region.

Symptoms.—When of recent date the discharge is thick and opaque, as in the later stages of catarrh or common cold, but as it becomes a settled condition it is subject to great variations, not only in respect of its consistence and character, but also as to the amount discharged. In the former connection it undergoes some remarkable changes, being at one time a thin, transparent, glutinous fluid, and at another thick, white, or even curdy-looking matter. Where structural changes have taken place in the diseased membrane, the discharge may be streaked with blood, and in some instances largely mingled with it. The outflow is much greater at some times than at others, and especially when the head is depressed or lowered to the ground. Where the matter is long pent up in the cavities of the face it acquires an offensive odour, which may continue or pass away, to return from time to time at varying intervals. More or less constitutional disturbance is remarked in cases of some standing, and where a disagreeable odour is attached to the discharge. The coat becomes unthrifty and staring, there is general loss of condition, and the animal is easily fatigued. The submaxillary glands may become enlarged and hard-

ened, and the membrane lining the nostril assumes a leaden hue, symptoms which are also associated with glanders, and sometimes give rise to much anxiety and indecision in the matter of diagnosis, even among experts.

Treatment.—It will prove a safe plan in every case of nasal discharge and glandular swelling of a chronic kind to isolate the patient and keep for his particular use one set of stable utensils, harness, &c. Both local and constitutional measures of treatment should be adopted. Good sound food and a liberal allowance of it, exercise but not work, and good sanitary surroundings. Internal agents of the astringent tonic class are found to be very beneficial, and the salts of different metals may be administered and changed from time to time, the one for the other, with advantage. A course of arsenic and iron may be tried first, and should it not prove successful, then a change to the copper salts may be made. It is probable that all tonics are helpful, having regard to the relaxed state of the affected membrane. If it is decided to give arsenic, Fowler's solution should be chosen and given in the food in doses of from 1 to 2 ounces twice a day.

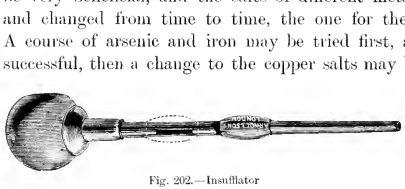

Fig. 202.—Insufflator

Local treatment of various kinds is recommended, and the agents employed are both wet and dry. The injection up the nostrils of astringent or styptic lotions with the aid of a syringe is not to be recommended, but the insufflation of iodoform by an instrument made for the purpose, and known as an *insufflator* (fig. 202), may be tried for a short period. It consists of an india-rubber ball, with a long vulcanite nozzle.

The lotions most favoured are those in which the sulphates of zinc, copper, and iron form the principal part, and in some severe cases a solution of chloride of zinc is used in the shape of Burnett's fluid. The patient is naturally alarmed by the use of nasal injections, and the success of the treatment depends largely upon the efficiency of the operator. There are cases that defy all treatment of this kind, owing to the inaccessibility of curative agents to the seat of disease; here the sinuses of the face may have to be trephined and the semi-solid matter removed (see "Operations"), after which the cavities will require to be repeatedly washed out with astringent and antiseptic solutions.

Fumigation of the nostrils (fig. 203) with warm vapour impregnated with volatilized carbolic acid or turpentine should be tried. This may be done by means of a nose-bag containing warm, moist bran or sawdust, over which a little of one or the other or both the agents named has

been sprinkled. The application should be made three times a day for not less than an hour on each occasion. In all cases of this kind the patient should be made to eat hay from the ground, so as to encourage the downward flow of matter from the cavities of the face. Where no benefit is derived from these several methods of treatment it may be desirable to wash out the sinuses of the face, but before this can be done one or more openings will require to be made into them by removing portions of bone, or, as it is termed, trepanning.

Fig. 203. Fumigation of the Nostrils for Catarrh

HEMORRHAGE

When blood escapes from the vessels into an open space, whether it be into one of the cavities of the body (chest or belly, &c.) or on to the surface, it is described as hemorrhage. If, instead, it passes into the tissues, as in the case of a black eye or a "corn", it is spoken of as extravasation. Bleeding may occur from an artery or a vein, or both at the same time. In the first case it is distinguished as arterial hemorrhage, in the second as venous, and in the third mixed.

For convenience of description different terms are employed to indicate the particular organs from which bleeding takes place. Thus bleeding from the nose is known as epistaxis (ἐπὶστταξειν, to distil), from the lungs as hæmoptysis (ἅιμα, blood, and πτυειν, to spit), from the stomach as hæmatemesis (ἅιμα, blood, and ἔμειειν, to vomit), from the ear, ottorhægia, &c. &c.

Causes.—Hemorrhage may be the consequence of either disease or accident. In some animals it originates in a congenital weakness of the vessels, in which case their walls give way under very trifling causes as when bleeding from the nose comes on in the course of a gallop, excitement, or effort in draught, or when hemorrhage from the lungs is provoked by coughing. Cases have come under the notice of the writer where, without any apparent cause, blood would ooze through the vessels of the skin and hang in drops from the hair at numerous points. This form of the disease is termed hæmophilia (ἅιμα, blood, and φιλειν, to love).

Hemorrhage as a result of disease is exemplified where the walls of the capillary vessels are weakened by fatty degeneration and fail to resist the pressure of the blood within them. The larger arteries sometimes become

dilated and ulcerated, and break, from the same cause. Sloughing ulcers of the bowels, stomach, and other organs may lay open the blood-vessels and lead to serious or even fatal extravasation.

The accidental causes of hemorrhage are wounds and blows, the former resulting from cuts, stabs, and lacerations of the flesh.

Symptoms.—Hemorrhage from the surface of the body is obvious, but internal bleeding is not always so. When it takes place into the lungs it may be evidenced by its escape from the nostrils; but when the escape is into the chest or belly, or other closed cavities, the outward indications of its occurrence must be sought for in certain manifestations of disordered function and physical signs. Of these the more suspicious are a pale or blanched appearance of the membranes lining the mouth, the nostrils, and the eyelids. The pupils of the eyes become dilated, and the eye itself presents a bright, glassy appearance. The breathing is deep and sighing, the extremities become cold, and patches of cold sweat appear on the body. The upper lip is raised from time to time, and if the head be elevated by placing the hand under the jaw, the animal staggers.

As the blood drains away, and supply to the brain fails, the muscles twitch and quiver and finally undergo general relaxation, when the body staggers and falls. Death from loss of blood is preceded by convulsions.

Treatment.—The course to be adopted in dealing with hemorrhage will depend upon the organ affected, and in external bleeding in some measure as to whether the flow is from an artery or a vein, or from smaller and less important vessels. If an artery be laid open through an external wound, the blood flows from it in jerks corresponding to the beating of the heart, and it is, besides, of a bright scarlet hue. If it proceeds from a vein, it passes from the wound in a continuous stream, and the colour is dark red or purple.

Where veins and arteries are divided at the same time these two colours are blended together, giving a colour intermediate between the two, or a light and dark streakiness, to the stream. If the vessel from which the blood escapes is of considerable size, and can be made accessible, the bleeding may be arrested by ligature, *i.e.* by tying it round tightly with a piece of clean carbolized silk or string. If it is an artery, the ligature should be applied to that side of the opening in the vessel nearest the heart, from which direction the blood is coming. If it be a vein, that side farthest from the heart will be selected. Pressure on the bleeding part, by means of the finger or a bandage, may suffice to stop the flow. Where the blood proceeds from a number of small vessels, a little cotton-wool applied to the broken surface will sometimes have the desired effect. Should it not do so, the part may be freely irrigated with cold water, or dressed with a solution

of perchloride of iron, alum, or sulphate of copper. The application of the actual cautery (hot iron) may be made in some cases where the divided vessel is not large. The internal administration of turpentine, lead, opium, or tannic or gallic acid will increase the coagulating power of the blood and assist in filling up the breach.

BLEEDING FROM THE NOSE—EPISTAXIS

In race-horses and hunters, when highly strung and in a plethoric condition, bleeding from the nose frequently occurs in the course of a race or the chase, and many a brilliant performer in either capacity has had his career cut short, and the hope and aspirations of both owner and trainer levelled to the ground, by the occurrence of this mishap.

Bleeding from the nose may be quite accidental, and it is by no means the case that its first occurrence should be followed by a repetition of the event. Where, however, this does occur, and the mishap is repeated from time to time, the existence of some structural weakness of the vascular system may be reasonably inferred.

It does not, however, follow that it should continue throughout life. Several instances are known to the writer where bleeding from the nose at two or three years old has repeatedly occurred, to disappear altogether at four or five; but it is poor consolation to an owner of promising and highly engaged youngsters to be told that the capacity for winning races will be reached when all the best opportunities have passed and the stakes safely landed by others.

Causes.—That weakness of the vascular system is hereditary is well affirmed in certain families of horses, no better example of which could be given than the descendants of that famous sire Hermit, several of whom were hopelessly afflicted as race-horses.

Bleeding from the nose is usually determined by some severe exertion, sudden effort, or excitement acting upon a naturally weak or over-distended state of the vessels. The latter condition is found in plethora, in congestion of the lining membrane of the nostrils, attendant upon cold and certain specific fevers. Sometimes it arises out of a superficial ulceration of the nostrils of a benign character, but more commonly in the destructive ulceration of glanders. It is also a prominent feature in that form of blood disease known as purpura hæmorrhagica.

Symptoms.—The discharge of blood may not be more than a few drops, or it may flow in a large and continuous stream. In the one case it is a matter of little moment, save as a warning of its possible recurrence, while in the other it may lead to serious mischief and give

rise to symptoms of an exhausting and threatening character, which we have fully described under the head of "Hemorrhage".

Treatment.—Perfect quiet and a cold stable are the first requirements in the treatment of epistaxis. In the choice of remedies the great object will be to cause the blood-vessels to contract and to hasten the formation of a clot of blood at the seat of rupture, and thus effect a stoppage of the escapement. These indications are most likely to be met by irrigating the face with ice-cold water from the poll downwards, or applying a bag of powdered ice over the entire region of the nostrils. Should this fail to meet the purpose, the injection of astringent solutions into the nostrils, or the insufflation of fine astringent powders, may be resorted to. The salts of iron, acetate of lead, or gallic or tannic acid will be found to answer the purpose best. Plugging the bleeding nostril with cotton-wool soaked with one or another of the astringent solutions referred to may be tried in severe cases, but its adoption requires care.

For internal remedies see "Hemorrhage".

Prevention.—Horses given to bleeding from the nose should not be put to severe work, neither should they be highly fed, and it is most desirable that food and water be given them two or, better, three hours before going to work. With the object of imparting tone to the vessels a dram of sulphate of iron should be given in the food twice daily for a fortnight or three weeks now and again.

PUS IN THE GUTTURAL POUCHES

The guttural pouches (fig. 204) are two somewhat capacious cavities situated between the base of the skull above and the pharynx and larynx below. The inner walls of the sacs are in apposition with each other, while their outer walls are for the most part covered with the parotid glands. They communicate with the pharynx by two openings—the eustachian tubes, and their function would appear to be in some way connected with the sense of hearing, and at the same time to allow the free expansion of the pharynx in the act of swallowing and of the larynx in breathing.

They are lined by mucous membrane which is continuous with that lining the throat. It occurs, therefore, that inflammatory affections of the latter sometimes extend to the former, as is now and again the case in strangles, influenza, and pharyngitis, with the result that one or both guttural pouches become more or less distended with pus.

Symptoms.—Here there is a chronic discharge from one or both nostrils, generally of an intermittent character, sometimes constant, but always variable in amount. The flow of matter is greatly increased under

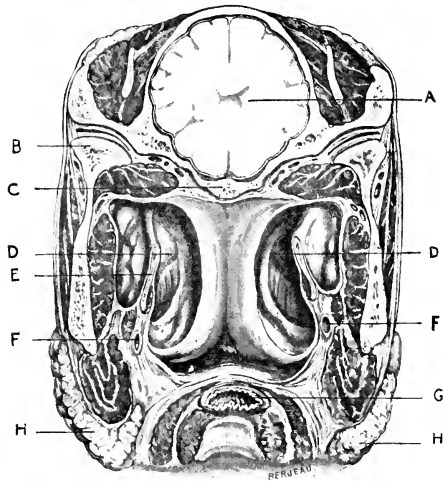

Fig. 204.—Transverse Section of Horse's Head, showing the Guttural Pouches

A, Brain. B, Maxillary Condyle. C, Sphenoid Bone. D, D, Guttural Pouches. E, Great Cornu of Hyoid Bone. F, F, Eustachian Tubes. G, Œsophagus. H, H, Parotid Glands.

certain conditions, notably when the head is held low, as in eating and drinking from the ground. During mastication coughing is induced in the act of swallowing, when the pellet of food is sometimes expelled from the mouth into the manger. In some cases of this kind, where post-mortem examination has been made, the pus has been found to have formed itself into numerous solid concretions varying in size from a pea to a walnut, some being rounded, others angular and faceted masses (fig. 205). In structure all are laminated or formed in layers.

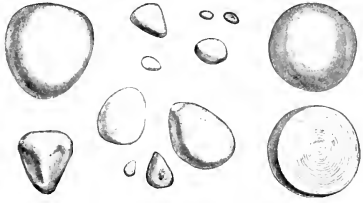

Fig. 205.—Concretions of Pus from the Guttural Pouches

The presence of angular specimens shows them to have existed some considerable time, and, by rubbing one against another, to have worn down the original rounded surface into a number of facets.

The disease may be confined to one pouch, or extend to both. The affected side of the throat in the region of the parotid gland is full or distinctly swollen. Pressure applied to this part induces pain, and if deep pressure be made, matter is sometimes caused to flow from the nostrils in large amount. If the escape of pus be prevented by partial or complete closure of the escape holes in the enstachian tubes, the accumulation of matter becomes so great as to interfere with swallowing, and pressure on the larynx induces a noisy or roaring sound in breathing. Under these circumstances the outward swelling would be very considerable and marked by distinct fluctuation.

Treatment.—It is frequently the case that this abnormal condition of the guttural ponches is in existence for a considerable time before it is recognized. The continuous discharge from the nostrils following upon strangles and influenza is generally regarded as the result of a catarrhal state of the nasal membrane, and it is not until some interference with swallowing, or breathing, or some enlargement in the region of the throat takes place that the actual state of affairs becomes recognized. Before proceeding to any heroic measures of treatment, it may be desirable to try the effects of a run at grass and a blister to the throat. As the downward position of the head assumed in grazing favours the discharge of the matter, and the emptying of the sac, this may have the desired effect. Should it not do so, then the distended pouch or ponches will require to be punctured and their contents evacuated. This is an operation that calls for expert assistance, as there are numerous important vessels and nerves in the region of the throat which it would be dangerous to injure.

The operation consists in cutting through the skin behind the posterior edge of the parotid gland, about 4 to 5 inches below the ear, and over the seat of the most fluctuating point. This having been done, a hole is made into the pouch either by dissection or, what is safer, by carefully thrusting a blunt-pointed instrument something like a pen-holder, but having a wider base, through the tissues into the sac, and then cautiously enlarging the opening upward and downward with the knife. When the sac has been emptied, it should be thoroughly washed out with a weak solution of carbolic acid. This should be done, if possible, while the horse's head is inclined downwards, which position he may be made to assume by feeding him on the ground. As a repetition of the injection will require to be made on the two following days, the aperture should be kept open

by introducing into it a piece of india-rubber tubing and keeping the patient tied up by the head. The subsequent injections can then be made through the tubing.

DISEASES OF THE LARYNX

Diseases of the larynx more especially involve the mucous membrane by which it is lined. Of these the more common are: (1) Laryngitis or inflammation; (2) ulceration; (3) œdema or effusive swelling. In addition, it is also liable to disorder of the nerves, by which its movements are regulated. These neurotic disturbances are represented by (*a*) paralysis, (*b*) spasm. Morbid growths, in the form of tumours or polypi, are also now and again accountable for laryngeal trouble.

Laryngitis, or inflammation of the larynx, although by no means a common disorder in the horse, is nevertheless of serious import when it assumes a severe or acute character. In some instances it proves rapidly fatal, as the result of asphyxia or suffocation following upon swelling of the inflamed membrane and consequent narrowing of the breathing aperture. In others it runs a less acute course, and when the disease subsides leaves behind a more or less lingering irritation, attended with chronic cough, and maybe difficulty of breathing.

Causes.—Laryngitis is more especially seen in stabled animals, and frequently results from exposure to cold and wet after severe exertion, or from sudden changes of temperature in animals occupying hot, badly-ventilated stables. It may also arise out of a common cold, or may appear in the course of an attack of influenza, or strangles, or as the result of the specific poison of glanders, or purpura hæmorrhagica. Operations on the larynx for roaring are sometimes followed by it, and we have known it to be induced by the lodgment of foreign substances in the laryngeal cavity. Air charged with irritating vapours is also capable of exciting laryngitis in susceptible subjects.

Symptoms.—The symptoms of the disease will vary with the severity of the attack. When it arises out of cold, it is commonly preceded by the ordinary symptoms of that ailment. Usually its onset is marked by general indications of illness, evinced by slight dulness, impaired appetite, increase in the body temperature, quickened pulse, and maybe more or less soreness of the throat. Where no such premonitory symptoms appear the disease is ushered in by a severe and painful cough, which comes on in paroxysms. In character the cough is harsh and coarse, and the painful nature of the act is denoted by the effort which the patient appears to make to suppress it, and the restlessness and excitement it induces. Pres-

sure on the throat gives rise to pain, and its soreness is further shown by difficulty in swallowing, the food being altogether refused, or dropped from the mouth after partial mastication. The nose is protruded, the breathing is much interrupted, each act of inspiration being prolonged and laboured, and attended by a coarse, hissing, wheezing, or roaring sound, sometimes loud enough to be heard at a considerable distance. Intervals of relief occur now and again, when the symptoms of distress subside and the breathing becomes less noisy. As the disease progresses the face wears an anxious expression. The membrane of the eye and nose is of a dark-red or livid hue—denoting imperfect aeration of the blood, which leads the animal to seek for air and turn to the door whenever it is opened. The pulse is quick, full, and firm, and the legs are cold. In the paroxysms of threatened suffocation the animal paws the ground with the fore-feet, shakes the head violently, and breaks out into patchy sweats.

Treatment.—In the treatment of laryngitis it is of the first importance that the patient be provided with a thoroughly clean stable, and that the air be kept free from contamination with the products of decomposition and irritating substances, both solid and gaseous. Nothing tends so much to aggravate the disease as an atmosphere charged with ammonia and other products of putrefaction. It is equally important to keep down the dust of the stable, which, in passing over the larynx, serves to provoke coughing and add to the breathing trouble. Ventilation should be free, but it is at the same time desirable that the temperature of the stable should not be allowed to fall beyond 55°, or, better still, maintained at 60°, and it is to the advantage of the patient if the air be kept moist. This may be done by introducing pails of boiling water into the stable, from which warm vapour will be given off.

These provisions having been carried out, the surface warmth is to be maintained by ample clothing. The food should be warm, soft, and succulent, and given in small quantities, and often. Bran scalded with hot linseed-tea and mixed with boiled carrots or roots, and given while warm, is the most suitable diet. As a change a few creed oats may be added, or a little boiled oatmeal. Or the patient may be allowed to pick a little scalded hay from a pail while it is still hot. With regard to medicines, it should be borne in mind that where difficulty of swallowing exists the forcible administration of draughts and balls must not be attempted. Small quantities of an electuary, composed of belladonna, chlorate of potash, and treacle may be inserted into the mouth on a stick every three or four hours, when the animal will suck it in. In the act of swallowing it will be conveyed to the throat, and there exercise its soothing influence on the inflamed part. Considerable relief will be afforded by causing the

animal to inhale warm vapour from scalded bran contained in a nose-bag. Outwardly, hot cloths, or a linseed-meal and bran poultice, should be applied to the throat, or mustard may be employed instead, or a weak cantharides blister. When, as sometimes occurs, the breathing becomes difficult and attended with a loud roaring noise, the operation of *tracheotomy* should be promptly performed. This consists in cutting a hole into the windpipe, through which the patient is made to breathe by means of a tube inserted into it (fig. 206). Instant relief follows the operation, and on the subsidence of the disease the tube is removed and the wound allowed to heal. Tracheotomy should not be attempted by any but a qualified veterinary surgeon. Where, as usually occurs in severe attacks, solid food is altogether refused, the strength must be upheld by a liberal supply of eggs and milk, or even beef-tea in linseed or oatmeal gruel. If prostration and weakness are marked, a little spirits of wine may be added to the gruel twice or thrice a day.

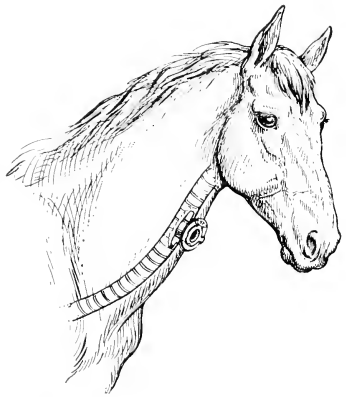

Fig. 206.—Tracheotomy Tube inserted in the Windpipe

Acute attacks of laryngitis not unfrequently leave behind chronic changes in the mucous membrane. It may, for instance, become thickened and irritable, in which case the breathing will be interfered with and a troublesome cough remain for a longer or shorter period. Ulceration of the larynx, beginning in the glands of the mucous membrane, paralysis of the muscles of the organ, ending in roaring, and, lastly, small tumours, are also consequences of this disease.

A course of iodide of potassium and mineral tonics should always be resorted to after the acute symptoms have subsided, in anticipation of one or the other of the changes noted, and an iodine blister to the throat, repeated two or three times at suitable intervals, will also assist in re-establishing a healthy condition in the diseased organ.

Roaring and Whistling.—Roaring and whistling are defects of respiration, arising out of a diseased condition of some portion of the air-passages, whereby one or the other of these sounds is produced, according to the nature and degree of the obstruction. As usually met with, it is a chronic and incurable disease, resulting from paralysis of the dilator muscles of the larynx. Less frequently it arises from other causes of a temporary character.

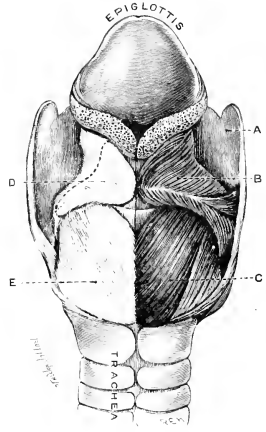

Fig. 207.—Larynx of a "Roarer"

A, Thyro-arytenoid Cartilage. B, Arytenoid Muscle. C, Crico-arytenoid Muscle. D, Left Arytenoid Muscle (atrophied). E, Left Crico-arytenoid Muscle (atrophied).

Causes.—Perhaps no equine affection has attracted more attention from veterinary authorities than this, and the opinion is universally held by them that in a large measure heredity is responsible for its wide prevalence. Most people, whether interested in horses or not, have had the subject forced upon their attention from time to time in connection with turf celebrities, and if the hereditary character of roaring had been more generally accepted in the early days of horse-racing there is no doubt that both our thoroughbred stock and their half-bred produce would have been less subject to the malady than they are now known to be. So many celebrated roarers have gone to the stud that persons best acquainted with the stud-book tell us it is difficult to find a thoroughbred horse whose progeny are absolutely free of roarers. Be this as it may, the race-horse of to-day is so susceptible that the slightest cough in a favourite animal spreads dismay among owners and trainers, and a large section of the general public not unfrequently share in the alarm. Chronic roaring is generally referable to wasting of the dilator muscles of the larynx, following upon a cold, an attack of influenza, or strangles, or some affection of the chest, all of which appear to have the effect of causing paralysis of the nerve of supply to the parts affected; or it may, and does, come about while an animal is in the best of general health. Numerous dissections prove that the left side of the larynx is almost invariably diseased, and the theory is suggested that this nerve (the left recurrent branch of the pneumogastric)

is rendered specially liable to derangement, in consequence of its having to wind round one of the larger vessels (aorta) emerging from the heart before ascending the neck. This conclusion may or may not be the correct one, but the fact remains that the right nerve, which does not take this course, is seldom or never affected. Microscopic examination of the nerve trunk has failed to elicit any information as to the intimate cause of the paralysis, as no change in the structure of the fibres is observable, and we are left to assume that whatever interruption there may have been in the nerve current during life it was not of this nature. In its chronic form roaring prevails in males to a much greater extent than in females, and more frequently in stallions than geldings. It is seldom or never seen in ponies under 14 hands, and the liability to the disease increases with the height of the animal and the length of neck.

Acute Roaring.—We have hitherto spoken of the one principal cause of roaring, but, as we have already pointed out, there are others of a less serious character, and some of them amenable to treatment. It will be understood that any obstruction to the free ingress and egress of air in the respiratory passage, and especially that portion of it which extends from the nostrils to the lungs, may have the effect of producing a roaring noise. A horse will roar when any tumour or obstructive thickening exists in the nasal chambers, or from any undue pressure on the windpipe. Roaring may also be induced by pressure on the larynx, by an accumulation of "matter" in the guttural pouches, by an enlargement of the glands of the throat, or by a spasmodic contraction of the muscles. Moreover, it may, and does, too frequently result from distortion of the larynx following the abuse of the bearing rein, but whether this is the explanation or not it is difficult to say.

Symptoms.—That grunting is a common accompaniment of roaring is so well known among horse-dealers that they may be seen, in auction sale-yards and other confined places, threatening the animals with a stick to see if they grunt with fear, and pinching the throat to provoke a cough the quality of which is in a certain measure, and to an experienced man, a guide to the existence of the disease. Though roarers very frequently have this deep cough, which is a mixture of groan and cough, there are many horses only moderately affected with the malady, who do not, and will not, cough when the larynx is pressed, as there are also whistlers who do not grunt on a feint being made to strike them. It has also to be borne in mind that many horses of nervous temperament, and others when out of condition, will grunt on being threatened with a stick, although perfectly sound in the wind.

In this affection the patient, while at rest, shows no symptoms, nor

are any awakened, save in bad cases, in the slow paces, and it is not until the animal is galloped, or, in the case of a harness-horse, compelled to draw a load uphill, or move at a quick pace, that the respiratory trouble becomes apparent.

Paralytic roaring usually comes on gradually, and shows but little variation in its severity, and in this respect it differs from spasm of the larynx, which is sudden in its onset, remains only for a brief period, and as suddenly disappears.

Treatment.—If roaring is the result of paralysis of the laryngeal muscles treatment is not hopeful, and to steady its further progress and palliate the symptoms is as much as we may look for.

Various attempts, surgical and otherwise, have been made to afford relief to the disabled organ. The most recent of these consisted in the removal of that part of the larynx (arytenoid cartilage) over which the muscles had ceased to exercise control, and whose displacement constituted the immediate cause of obstruction to the ingress of air in the act of breathing. Although the operation referred to cannot be said to have been followed by an encouraging measure of success it cannot be regarded as an unqualified failure, as in the hands of the writer it has had the effect in several instances of restoring useless animals to a state of usefulness. The method most commonly adopted for aiding respiration in these cases is that of inserting a tube into the windpipe about one-third of the distance down the neck. Through this artificial channel respiration can be efficiently carried on without the objectionable noise and premature distress resulting from the disease, and by its use the animal's services may be considerably prolonged and his comfort under exertion very materially enhanced. It is, however, at the best an unsightly expedient, and not altogether unattended with pain, while sooner or later the irritation induced by the tube will provoke an outward or inward growth of "proud flesh", rendering a further operation necessary, or maybe the destruction of the animal. All horses suffering from this disease should be kept in high condition. Throwing them out of work and "letting them down" adds considerably to the embarrassment of the breathing, if it does not also expedite the disease. In those cases where the breathing is left defective after an attack of cold, influenza, or strangles, no time should be lost in applying a counter-irritant to the throat, such as mustard or turpentine liniment, and a repetition of the application should be made at intervals for several times. Moreover, paralytic roaring should be anticipated by the early administration of full doses of nux vomica.

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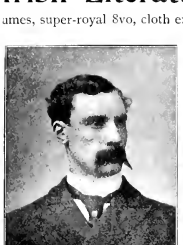

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It gives, in brief pointed biographical notices, the life-history of every great Irish writer. We are enabled to realize the personality of the man as well as appreciate the qualities of his work.

It deals not only with the past but with the present; and it is the only work that brings home to us by illustrative extracts the great revival in Irish Literature that is now taking place. W. B. Yeats, Douglas Hyde, George Bernard Shaw, Nora Hopper, Seumas MacManus, Richard Ashe King, George Egerton, Moira O'Neill, are a few among the many scores of modern writers whose works are represented in the CABINET.

No Irishman who is proud of his nationality can afford to be without a work which thus focuses the whole intellectual activity of the race. To the younger generation it will be an inexhaustible source of inspiration, a priceless influence in forming their taste, in moulding their character—in a word, in perpetuating those qualities which now, as in the past, are associated with the name of Irishman.

The CABINET was originally planned by Mr. Charles Anderson Read, but this accomplished Irish poet and novelist did not live to see the fruition of his hopes. His work was completed by Mr. T. P. O'Connor, under whose auspices the first edition was issued. Now, after the lapse of nearly a quarter of a century, the time has come for a new edition of this monumental work, which shall take due account of the extraordinary activity in Irish letters during the intervening years. Under the able editorship of Miss Katharine Tynan (Mrs. Katharine Tynan Hinkson), herself one of Ireland's most distinguished writers, the work has been thoroughly revised and brought down to the present hour.

F. Frankfort Moore

In its get-up it is all that a book of its great importance should be. The illustrations are many and of the highest artistic value. Some of the most eminent black-and-white artists of the day, including John H. Bacon, Charles M. Sheldon, W. Ranney, R.I., G. P. Jacomb-Hood, R.I., and W. H. Margetson, have been commissioned to illustrate typical scenes from the masterpieces of our literature, and these drawings, rendered by the latest processes of photographic reproduction, and printed on specially prepared paper, add an unique charm to the work. The CABINET is further embellished with a large number of photographs of the most eminent Irish writers; and the cover design, in gold upon green cloth, is the work of Talwin Morris, the well-known designer.

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The Book of the Home.

AN ENCYCLOPÆDIA OF ALL MATTERS RELATING TO THE HOUSE AND HOUSEHOLD MANAGEMENT. Produced under the general editorship of H. C. DAVIDSON, assisted by over one hundred specialists. Copiously illustrated by coloured and black-and-white plates and engravings in the text. In 4 volumes, super-royal 8vo, cloth, with artistic design; also in 8 divisional volumes, cloth.

THE BOOK OF THE HOME is intended to form a complete work of reference on all subjects connected with household management. No efforts have been spared to ensure that every matter bearing upon the Home and Home Life shall receive full and sufficient treatment, and that the information given shall be reliable and in the best sense of the phrase up-to-date.

A few among over one hundred specialists who have contributed to the work:

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Miss BERTHA BANNER, Training Teacher of Sewing and Dressmaking at the Liverpool Technical College for Women.

Mr. A. BLACK, C.E., Architect, Author of *First Principles of Building*.

Mrs. DAVIDSON, Author of *Dainties*, *What our Daughters can do for themselves*, &c.

Miss J. FORSTER, Principal of the Cheshire County Council Dairy Institute.

Mrs. E. R. HAWEIS (the late), Author of *The Art of Decoration*, *The Art of Beauty*, &c.

Miss HELENA HEAD, Principal of the Liverpool Girls' School for Secondary Education in Domestic Science, and Author of the *Manual of Housewifery*.

Mrs. A. HODGSON, Home Decorator to *The Lady*.

Mr. R. KEITH JOHNSTON, Author of *Household Difficulties and How to overcome Them*.

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Miss E. E. MANN, Head Teacher at the Liverpool Training School of Cookery.

Colonel M. MOORE-LANE, Contributor to the *Field* and other agricultural papers.

Mrs. C. S. PEEL, Dress and Household Editor of *Hearth and Home*, and Author of *The New Home*.

Miss B. SIETHORPE POOLEY, Lecturer to the Liverpool Ladies' Sanitary Association.

Miss RANKIN, Head Teacher of Laundry Work at the Liverpool Technical College for Women.

Miss FLORENCE STACPOOLE, Lecturer to the National Health Society and the Councils of Technical Education, and Author of *Handbook of Housekeeping for Small Incomes*, &c.

Mr. DAVID TOLLEMACHE, late editor of *The Chef and Connoisseur*.

The contents of THE BOOK OF THE HOME may be grouped under four heads. The first deals with all matters concerning the House—from the choice of its site to the least of its internal decorations. The householder is instructed in the laws regarding landlord and tenant, and counselled in the important matters of sanitation and ventilation, heating and lighting, and the stocking and management of the garden. The housekeeper is advised as to furnishing, everything necessary for the comfort and adornment of a well-equipped house being described in detail, hints being also given regarding removals, painting and papering, artistic decoration, arrangement of linen and store cupboards, &c.

In the second the daily routine of the Household is considered—the duties of the servants, their wages, their leisure and pleasures, the management of the kitchen, laundry, and store-room. Plain and fancy cooking receive due attention, recipes being given of a large variety of dishes, and suggestions made for breakfast, lunch, afternoon-tea, dinner, and supper. A number of menus are added suitable for the different seasons. Invalid cookery also has its special section.

In the third are discussed the legal and customary duties, and the occupations and pastimes, of Master and Mistress, the former being instructed as regards insurance and the making of a will and the smaller matters of carving, the care of the wine-cellar, and the inspection of garden and stables, while the latter is advised as to account-keeping, payments, shopping, and innumerable other matters connected with her duties as Mistress. Other subjects treated under this head are dress, home occupations, visiting and entertaining, and indoor and outdoor amusements.

In the fourth sound, systematic, and practical advice is given as to the management, in health and sickness, and the education, of children, and also on such important subjects as occupations for boys and girls, the ceremonies necessary on the coming out of a daughter, and the preparations and formalities necessary before and after a marriage.

THE BOOK OF THE HOME will thus be at once an indispensable ally to the young bride and the novice in housekeeping, and a valuable work of reference to the more experienced.

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The Natural History of Animals:

The Animal Life of the World in its various Aspects and Relations. By J. R. AINSWORTH DAVIS, M.A., of Trinity College, Cambridge, and of University College, Aberystwyth. Profusely illustrated with full-page colour and black-and-white plates, and engravings in the text, by eminent animal artists. In 8 half-volumes, cl. extra; also in 4 volumes, Roxburgh binding.

While the sum of human knowledge is gigantic now as compared with what it was a hundred years ago, in the department of Natural History the books upon which the great majority of us must depend have undergone practically no change. The general Natural History still follows the lines adopted by Goldsmith in his famous and delightful *Earth and Animated Nature*. That is to say, they are little more than classified catalogues of animals, taking up in succession the various groups and individuals, and describing them one after another, each as standing by itself. This is not what the intelligent reader of the present day requires. He must be put in a position to take a comprehensive grasp of the subject; he demands a competent guide, not a directory, however accurate.

It is with this end in view that THE NATURAL HISTORY OF ANIMALS has been compiled. It treats this great subject on essentially modern lines, giving an accurate and vivid account of the habits, relationships, mutual interdependence, adaptation to environment, &c., of the living animals of the world.

It is needless to say that the production of such a work demanded a man who has devoted his life to the study of biology and zoology, and who at the same time is a gifted writer and expounder. This rare combination has been found in the person of Prof. J. R. AINSWORTH DAVIS, M.A., of Trinity College, Cambridge, and of University College, Aberystwyth, the author of the present work. Prof. DAVIS is well known to naturalists as an ardent worker in Natural History, particularly in the field of marine zoology. He is a very distinguished graduate of Trinity College, Cambridge, the chief scientific school in Britain, perhaps in the world, and has done a great deal of literary work, both scientific and in other directions.

Briefly, **the object of Prof. Davis's work** is to give in a readable form and in non-technical language a general survey of the whole animal world from the stand-point of modern science—and the work may fairly claim to be a **Natural History on a new plan**, the first comprehensive work in English of its own special kind. Formerly Natural History had much the character of a miscellaneous aggregate of disconnected facts, but hardly any fact or feature connected with any animal can now be considered as isolated from others; and animals as a whole must be looked upon as interrelated in the most surprising manner both with one another and with their surroundings.

Every household library should contain a Bible, a Dictionary, an Encyclopedia, and a work on Natural History. This is the "irreducible minimum", other books we may have, these we must. For THE NATURAL HISTORY OF ANIMALS it may fairly be claimed that it has a better title than any other work to become the **Natural History for the Household**. It is a work in which the adult reader will find a never-failing mine of information, while the younger members of the family will delight in its wealth of illustration, and its store of interesting and suggestive anecdote.

To teachers THE NATURAL HISTORY OF ANIMALS may be regarded as indispensable. More than usual attention has of late been directed to the important subject of **Nature-study**; and in this respect the appearance of Prof. Davis's work could scarcely have been more fitly timed. In the domain of Natural History it is pre-eminently the book for the purpose. Its clear and orderly arrangement of facts, its masterly grasp of general principles, its comprehensiveness of scope and simplicity of style, combined with the most absolute scientific accuracy, render this work an invaluable book of reference for those who aspire to teach Nature-study on up-to-date principles.

The Illustrations, as befits a work of such importance, are on the most lavish scale. A large number are in colour, reproductions, by the latest processes of colour engraving, of exquisite pictures by the most eminent animal draughtsmen. In illustrating the work talent has been sought wherever it was to be found; and the list of artists is representative of several nationalities. A large number of the designs are the work of Mr. A. FAIRFAX MUCKLEY, who is probably unsurpassed in the capacity to depict living creatures with absolute fidelity to detail without sacrificing the general artistic effect. FRIEDRICH SPECHT, one of the most eminent German animal painters of the past century, is represented in THE NATURAL HISTORY OF ANIMALS by many of his best designs in colour and black-and-white. W. KUHNERT, another German artist whose work is universally admired; and M. A. KOEKKOEK, the talented Dutch painter, are also among those who have assisted in the embellishment of the work. An important feature is the series of diagrammatic designs showing the structure of certain typical animals, specially drawn under the direction of Prof. Davis.

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The Modern Carpenter, Joiner, and Cabinet-Maker:

A Complete Guide to Current Practice. Prepared under the editorship of G. LISTER SUTCLIFFE, Architect, Associate of the Royal Institute of British Architects, Member of the Sanitary Institute, editor and joint-author of "Modern House-Construction", author of "Concrete: Its Nature and Uses", &c. With contributions from many specialists. Illustrated by a series of about 100 separately-printed plates and 1000 figures in the text. In 8 divisional volumes, super-royal quarto, handsomely bound in cloth, with cover design by Mr. TALWIN MORRIS; also in 2 volumes, Roxburgh binding. In complete sets only.

In preparing THE MODERN CARPENTER the editor has had the great advantage of working upon the basis of Newlands's *Carpenter and Joiner's Assistant*, which for nearly half a century has been accepted as a **standard authority** on the subjects of which it treats, and for many years has been recommended by the Royal Institute of British Architects as a **text-book** for the examination of that society. And yet in the present work it has been possible to preserve only a very small part of Newlands's treatise, invaluable though this has been to two generations of craftsmen. While the fundamental features of arrangement and method which distinguish this famous work have been retained, the matter has had to be **entirely rewritten**, and many new sections have been added, on subjects not touched upon in the older work, with which the carpenter of the present day requires to be familiar.

In the new book, indeed, the old foundations that have stood the test of half a century of practical use have been retained, but **the superstructure is wholly new.**

The lesson to be learned from this fact is not far to seek. It is that the modern carpenter requires a **far wider expert knowledge** than sufficed his predecessor. The development of wood-working machinery, the introduction of new kinds of timber, improvements in the design of structures, the more thorough testing of timbers, and progress in the various industries with which Carpentry, Joinery, and Cabinet-making are intimately allied, have all helped to render the craft more complex. The carpenter of the present day has no use for the old "rule of thumb" methods; his calling is both an art and a science, and **knowledge, knowledge, and again knowledge** is the primary condition of success.

The editor of THE MODERN CARPENTER, **Mr. G. Lister Sutcliffe,** Associate of the Royal Institute of Architects, **needs no introduction** to practical men; his name is already well known not only through his professional position in the architectural world, but through his editorship of *Modern House-Construction*, a work which, although issued only a few years ago, has already become a standard book of reference. Mr. SUTCLIFFE'S large experience has enabled him to enlist the services of a **highly-qualified staff of experts,** whose special knowledge, acquired through long years of practical work, is now placed at the disposal of every member of the craft. The first condition in selecting the contributors to the work was that they should be **practical men,** not only possessing the indispensable knowledge, but having the ability to impart it. The result is that within the eight divisional-volumes of this work we have a treatise on every branch of the craft, distinguished by four outstanding qualities:—It is (1) **complete,** (2) **clear,** (3) **practical,** and (4) **up-to-date.**

An idea of the scope of THE MODERN CARPENTER may be gathered from the fact that while its predecessor, *The Carpenter and Joiner's Assistant*, comprised only **eight** sections, the new work includes no fewer than **sixteen**. A glance at these will show that the work **covers the whole field**; it is a complete encyclopædia upon every subject that bears upon the everyday work of the practical man.

I. Styles of Architecture.
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XI. Cabinet-Making.
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The Illustrations are not the least of the many notable features of this great undertaking. The work is embellished in the first place with about **100 full-page plates,** reproduced, some in colours, by the most approved processes of mechanical engraving, and printed on specially-prepared paper. In addition to this unique collection there are no fewer than **1000 diagrams and designs** in the body of the work. No trouble or expense has indeed been spared to procure illustrations where these could elucidate the text.

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